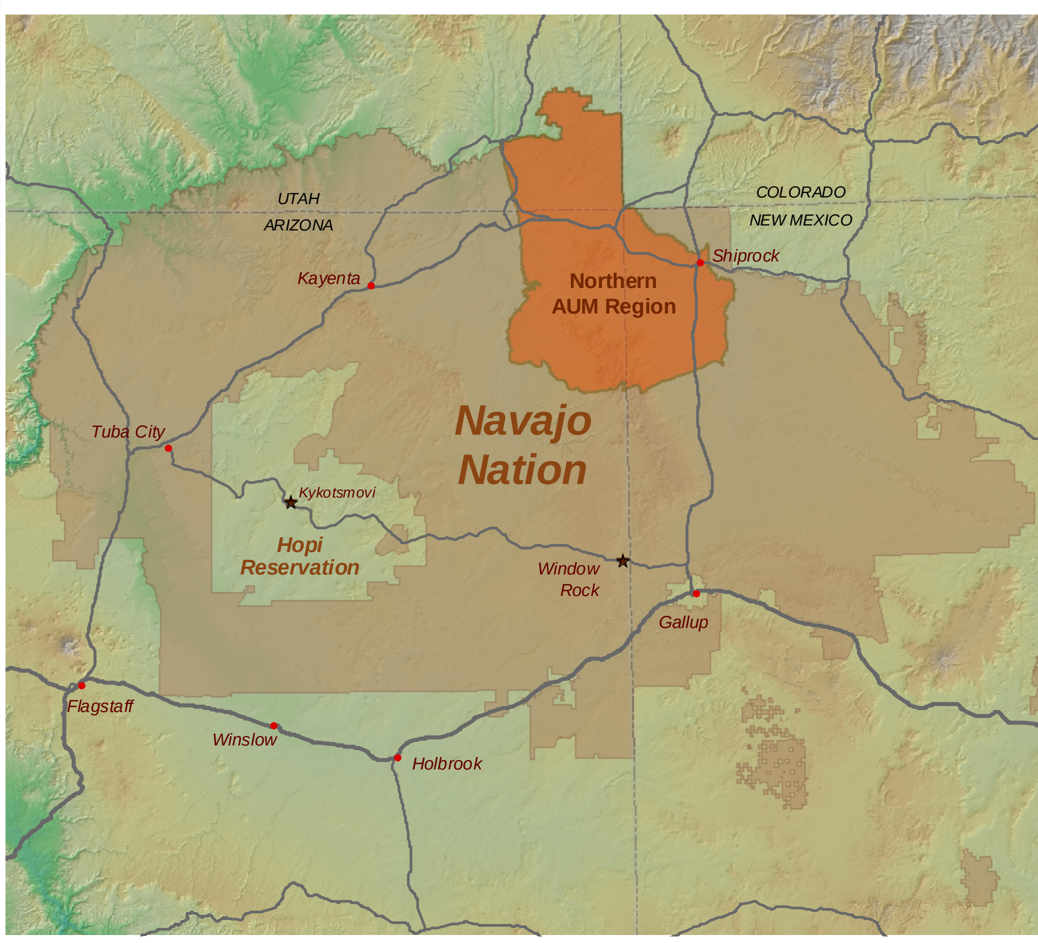
ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

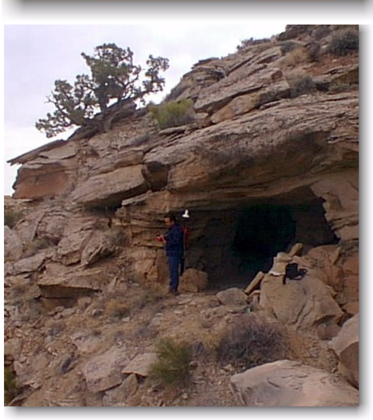
NORTHERN AUM REGION
SCREENING ASSESSMENT REPORT

Aneth, Beclabito, Cove, Lukachukai, Red Mesa, Red Valley, Round Rock, Sanostee, Shiprock, Sweetwater, and Teec Nos Pos Chapters





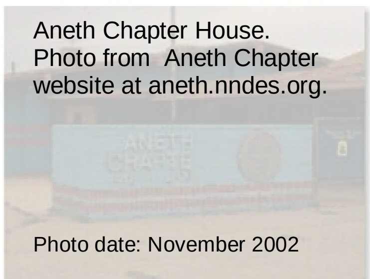


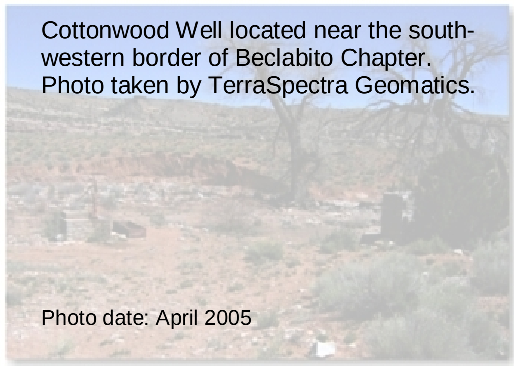

Navajo Nation
Environmental Protection Agency

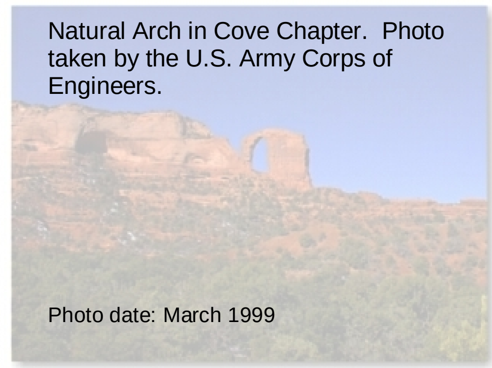
U.S. Environmental
Protection Agency - Region 9

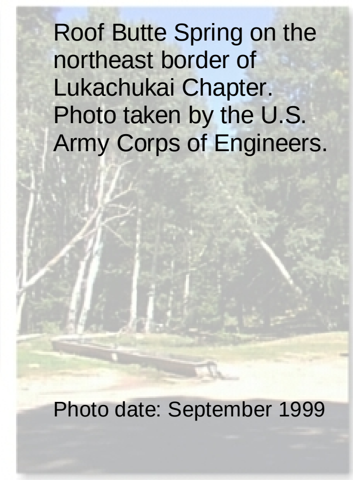
Navajo Abandoned
Mine Lands Reclamation Program

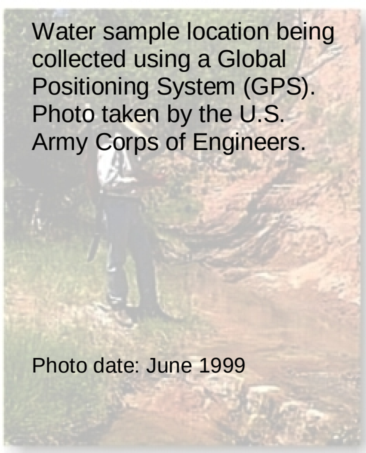
COVER PHOTOS

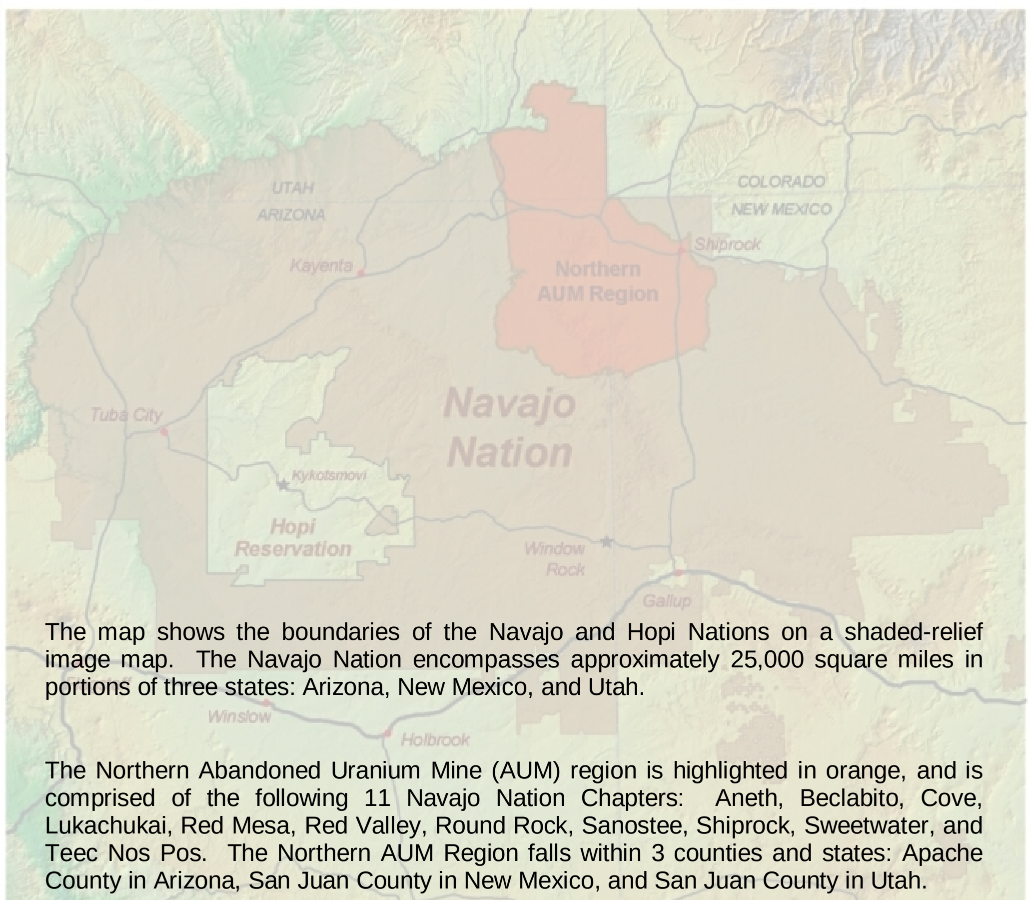

Aneth Chapter House. Photo from Aneth Chapter website at aneth.nndes.org.
Photo date: November 2002


Cottonwood Well located near the south-western border of Beclabito Chapter. Photo taken by TerraSpectra Geomatics.
Photo date: April 2005


Natural Arch in Cove Chapter. Photo taken by the U.S. Army Corps of Engineers.
Photo date: March 1999

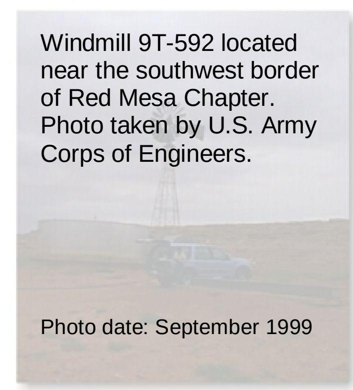

Roof Butte Spring on the northeast border of Lukachukai Chapter. Photo taken by the U.S. Army Corps of Engineers.
Photo date: September 1999


Water sample location being collected using a Global Positioning System (GPS). Photo taken by the U.S. Army Corps of Engineers.
Photo date: June 1999



The map shows the boundaries of the Navajo and Hopi Nations on a shaded-relief image map. The Navajo Nation encompasses approximately 25,000 square miles in portions of three states: Arizona, New Mexico, and Utah.

The Northern Abandoned Uranium Mine (AUM) region is highlighted in orange, and is comprised of the following 11 Navajo Nation Chapters: Aneth, Beclabito, Cove, Lukachukai, Red Mesa, Red Valley, Round Rock, Sanostee, Shiprock, Sweetwater, and Teec Nos Pos. The Northern AUM Region falls within 3 counties and states: Apache County in Arizona, San Juan County in New Mexico, and San Juan County in Utah.


Windmill 9T-592 located near the southwest border of Red Mesa Chapter. Photo taken by U.S. Army Corps of Engineers.
Photo date: September 1999

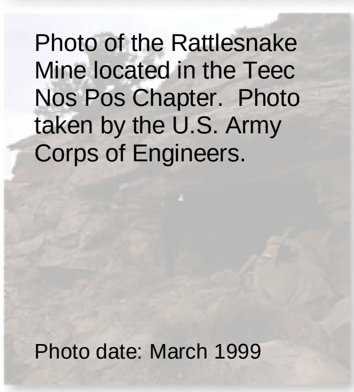
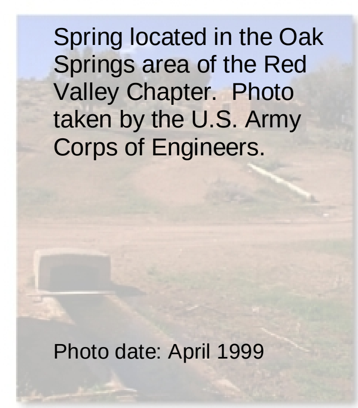


Photo of the Rattlesnake Mine located in the Teec Nos Pos Chapter. Photo taken by the U.S. Army Corps of Engineers.
Photo date: March 1999


Spring located in the Oak Springs area of the Red Valley Chapter. Photo taken by the U.S. Army Corps of Engineers.
Photo date: April 1999

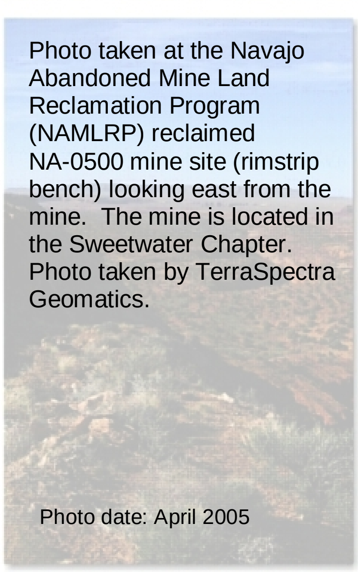
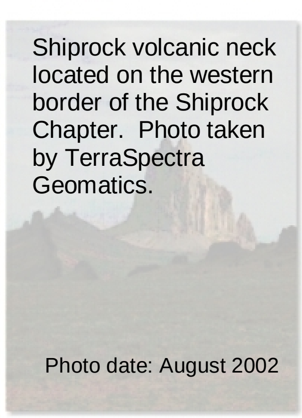
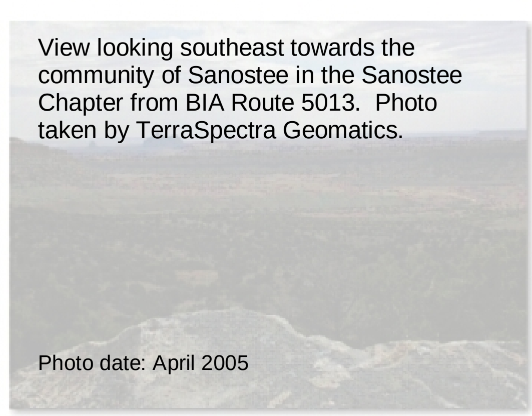
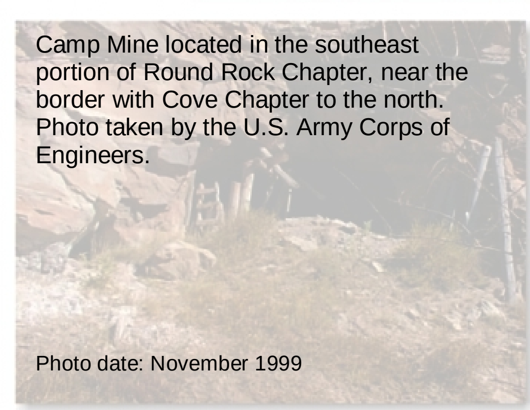


Photo taken at the Navajo Abandoned Mine Land Reclamation Program (NAMLRP) reclaimed NA-0500 mine site (rimstrip bench) looking east from the mine. The mine is located in the Sweetwater Chapter. Photo taken by TerraSpectra Geomatics.
Photo date: April 2005


Shiprock volcanic neck located on the western border of the Shiprock Chapter. Photo taken by TerraSpectra Geomatics.
Photo date: August 2002


View looking southeast towards the community of Sanostee in the Sanostee Chapter from BIA Route 5013. Photo taken by TerraSpectra Geomatics.
Photo date: April 2005


Camp Mine located in the southeast portion of Round Rock Chapter, near the border with Cove Chapter to the north. Photo taken by the U.S. Army Corps of Engineers.
Photo date: November 1999

Developed in Cooperation with:

Navajo Nation
Environmental Protection Agency
P.O. Box 339
Window Rock, Arizona 86515
Project Manager: Stanley W. Edison

Navajo Nation
P.O. Box 9000
Window Rock, Arizona 86515
Office of the President

Navajo Abandoned Mine Lands
Reclamation Program
P.O. Box 3605
Shiprock, New Mexico 87420
Project Manager: Melvin H. Yazzie

ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

NORTHERN AUM REGION SCREENING ASSESSMENT REPORT

NAVAJO NATION CHAPTERS INCLUDED IN NORTHERN AUM REGION:

Aneth
Beclabito
Cove
Lukachukai
Red Mesa
Red Valley
Round Rock
Sanostee
Shiprock
Sweetwater
Teec Nos Pos

Apache County, Arizona
San Juan County, New Mexico and
San Juan County, Utah

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Project Manager: Glynn R. Alsup

Prepared by:

TerraSpectra Geomatics
2700 E. Sunset Road, Suite A-10
Las Vegas, Nevada 89120
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March 2006

ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
NORTHERN AUM REGION SCREENING ASSESSMENT REPORT

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ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
NORTHERN AUM REGION SCREENING ASSESSMENT REPORT

COMMUNITY INTRODUCTION

In April 2000, the Navajo Nation Environmental Protection Agency (NNEPA), the Navajo Abandoned Mine Land Reclamation Program (NAMLRP)[1] and the United States Environmental Protection Agency (EPA) Region 9 made a decision to map and screen all abandoned uranium mines on the Navajo Nation for possible remedial actions. In addition to their own data, the three agencies collected information from tribal, state and federal agencies, including census, cultural, wildlife, and water resource agencies.

The Northern AUM Region screening assessment follows this introduction and provides valuable information and maps of mine locations, the mine type, and how close the mines are to homes and water sources. If you have questions about the information or about our programs or the science, please feel free to contact any member of our team listed in the contact information provided (see MISSION STATEMENTS). After all the data is collected, tribal and federal agencies will use the information to determine appropriate assessments, including possible cleanup actions.

For the purposes of this introduction, "abandoned uranium mines" are uranium mines that have been deserted, are no longer being maintained, no further mining is intended, and the mine may pose a hazard. Based upon several chapter meetings, the following are frequently asked questions that the agencies have been asked in their outreach work. These questions are important to people who live in areas with abandoned uranium mines. These questions focus on the environment and health.

ENVIRONMENT

1. *What are the impacts of abandoned uranium mines to the water we drink (groundwater and surface water)?*

   Uranium is a common, naturally occurring radioactive material that is present in our environment and may be found in water, soil, rock formations, and air. If water is present in the ground next to rocks containing uranium, there will be a certain amount of uranium in the water. Uranium in water comes from different sources. Most of it comes from the water running over uranium bearing rocks and through the soil. Only a small amount comes from airborne dust that settles on water. In some cases, the uranium can be suspended in water, like mixing dirt to make muddy water. Human activities, such as mining, can move the uranium around and change the levels that you are exposed to.

2. *What are the impacts of abandoned uranium mines to soil?*

   Mining practices at abandoned uranium mines often disturbed the natural makeup of soils, thus making them less stable and more susceptible to erosion. Concentrated ore was brought to the surface and indirectly caused the spread of contaminated soils in staging areas. During the digging, the sandstone rock containing the ore was separated by hand, loaded into trucks and transported off-site for milling. Uranium was also spread by erosion and blowing dust and can be found concentrated at the waste piles and ore transfer stations. Soils disturbed by mining are also likely to support less vegetation or they may support a totally new species mix due to the changes in soil composition. Several of these locations on the Navajo Nation have been assessed to identify areas of concern.

3. *What are the impacts of abandoned uranium mines to air?*

   In the air, uranium exists as dust. Very small dust-like particles of uranium in the air fall out of the air onto surface water, plant surfaces, and soil either by themselves or when rain falls. The amount of uranium dust particles in air is usually very small, so it is not considered a significant concern for health impacts.

HEALTH

Uranium is found everywhere naturally in small amounts. We take uranium into our bodies through the food and water we ingest and from the air we breathe. Additionally, we are exposed to radiation from cosmic and natural sources on earth all the time. In a few places, there is more natural uranium in water than in food. People living in these areas take in more uranium from their drinking water than from their foods. When we breathe uranium dust, some of it is exhaled and some stays in our lungs. The size of the uranium dust particles and how easily they dissolve determines where in the body the uranium goes and how it leaves the body. Some of the uranium dust may gradually dissolve and go into the blood. The blood carries the uranium throughout the body and most of it leaves in your urine in a few days, but a little stays in your kidney and bones.

1. *How far should I live from an abandoned uranium mine, whether it is reclaimed or not?*

   Reclaimed abandoned uranium mines should pose little risk for health hazards because work has been done to make the physical mine area safe and stable. The soils were carefully surveyed with radiation detecting equipment to identify problem areas. The uranium-contaminated soils were buried and many steep areas were stabilized to prevent further movement of the uranium containing soils. Drainage patterns have been diverted away from reclaimed areas to reduce the leaching capability of surface water. Any unreclaimed abandoned uranium mines may pose some risk. The agencies strongly advise people to reduce their exposure to places where there are abandoned uranium mines or mine wastes. People who already live near a mine, or a community considering an area for future development, will want to ask specific questions about a particular mine site or waste pile to better understand the risks. These questions are based on radiation safety principles known as ALARA (As Low as Reasonably Achievable), and follow three basic principles that can be applied to reduce potential exposures to radiation: time, distance, and shielding. Questions could include the following: How long is the person exposed, including residential, farming and recreational activities (time)? How close is the person to the source of exposure while doing these activities (distance)? Is there something between the person and the source of exposure that can absorb some of the radiation (shielding)?

   In the Northern AUM Region, the agencies looked at how close structures (e.g., homes, churches, businesses) were located to the mines to assess the potential for people to be exposed. This report serves as a tool for the agencies to discuss where cleanup decisions are needed, as well as how and who can address them.

[1] NAMLRP provided technical and review assistance to the project.

2. *What will happen if I drink water that contains small particles (dissolved) of uranium and heavy metals?*

The Navajo Nation issued a health advisory in 2001 recommending people drink water from regulated safe drinking water sources such as Navajo Tribal Utility Authority (NTUA) and Indian Health Services (IHS) systems. These sources of water are sampled and tested routinely to ensure it is safe to drink. Water containing natural uranium is radioactive, but only to a weak extent. At high concentrations, uranium also has a toxic, chemical effect, and people have developed kidney disease drinking highly contaminated water for long periods. This is why the EPA has established standards for uranium in drinking water throughout the United States which are safe for long-term water use. As long as the levels in the drinking water are below these concentrations, the water is safe to drink. The uranium drinking water standard is 30 parts per billion. Please refer to the EPA website for the list of drinking water standards for other elements of concern, including arsenic and lead: *http://www.epa.gov/safewater/mcl.html* . For more information on the health effects of uranium, arsenic and lead, please refer to the Agency for Toxic Substances and Disease Registry website: *http://www.atsdr.cdc.gov/toxfaq-u.html#bookmark05*

In the Northern AUM Region, we looked at how close water sources (for example wells, springs, and stock tanks) were located to the abandoned uranium mines to assess the potential for people to be exposed. Please see Figures 6 through 18 for maps showing the locations of water sources and mines within the Northern AUM Region.

3. *What are the effects of ingesting uranium that has been taken up by livestock*

There is not enough research in this area, but it is advisable that livestock not graze on areas where abandoned uranium mines are located.

4. *What can people do to reduce the risk of exposure to uranium?*

The most common and easiest things to do are the following:

- Avoid abandoned uranium mines, waste piles, or mill tailings piles.
- Do not collect any rocks from the vicinity of known uranium mines, waste ore piles, or transfer stations.
- Do not use suspect rocks for building homes, foundations, root cellars, corrals, bread ovens, fireplaces, or any other structures.
- If you have yellowish rocks or any rock you know that has come from a uranium mine area in your home or yard, call the Navajo Superfund Project Manager at 888-643-7692 or 928-871-6859 for additional information.
- Do not drink from unregulated water sources such as windmills, stock tanks, and springs.

5. *Is it safe to wash dishes or laundry with contaminated water?*

No, the agencies recommend using water from a regulated source such as NTUA and IHS systems.

If you have questions about your drinking water quality, please contact NNEPA Public Water Supply at 928-871-7715. You can reach NTUA at 928-729-5721.

Radiation Exposure Compensation Act (RECA)

Where can I apply for Radiation Exposure Compensation Act (RECA) benefits?

The Uranium Office in Shiprock, New Mexico can provide application packets and pertinent information for miners, transporters, millers, and down winders.

Larry Martinez
Uranium Office
Post Office Box 1890
Shiprock, New Mexico 87420
Telephone: 505-368-1261 Fax: 505-368-1266

Uranium Office
Post Office Box 1079
Tuba City, Arizona 86045
Telephone: 928-283-3008 or 928-283-3009

Radiation Exposure Screening and Education Program (RESEP)

Where can I get screened for compensation requirements under the Radiation Exposure Screening and Education Program?

The following are screening facilities:

Shiprock Northern Indian Health Service
Post Office Box 160
Shiprock, New Mexico 87420
Telephone: 505-368-7032

RESEP Coordinator
Montezuma Creek Clinic
Post Office Box 130
Montezuma Creek, Utah 84534
Telephone: 435-651-3291

RESEP Coordinator
Lake Powell Medical Center
Post Office Box 1625
Page, Arizona 86040
Telephone: 928-645-8123, ext. 206

RESEP Coordinator
North Country Community Health Center
2301 N. 4th St, Suite 101
Flagstaff, Arizona 86003
Telephone: 928-779-7277

MISSION STATEMENTS

NAVAJO NATION ENVIRONMENTAL PROTECTION AGENCY

On April 21, 1995, the Navajo Nation Council established the Navajo Nation Environmental Protection Agency (NNEPA). NNEPA is an independent regulatory agency within the Executive Branch of the Navajo Nation Government with regulatory, monitoring, and enforcement authority over matters relating to the quality of the environment and over any person or entity doing business within, or otherwise affecting the environment of the Navajo Nation.

On May 22, 2001, the NNEPA received approval to amend the plans of operations for the Air & Toxics Department, the Surface and Ground Water Protection Department, the Waste Regulatory & Compliance Department (WRCD), and the Criminal Enforcement Department. The first three departments are responsible for the civil and administrative enforcement of Tribal environmental laws and regulations. Criminal environmental crimes are investigated by the Criminal Enforcement Department.

Each department consists of several programs that are responsible for program development, technical and enforcement development, conducting research, investigating and assessing environmental problems and concerns, monitoring cleanup and/or corrective actions, and providing technical assistance and training.

Funding for NNEPA is provided by Navajo Nation general funds, federal grants from the U.S. Environmental Protection Agency (EPA), the U.S. Department of Justice, and from fees that are collected under existing Tribal environmental laws.

The Navajo Superfund Program (NSP) is one of several programs within the WRCD. The NSP is funded by an EPA grant under the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund. Under CERCLA, NSP is responsible for conducting site assessments where hazardous substances may have been used by past activities, such as uranium mining and milling activities that occurred in the Northern AUM Region.

NSP has conducted assessments at the King Tutt Aggregated Uranium Mine Site. These activities included collecting samples of soil sediments and both surface and ground water. Other activities included conducting surveys using instruments to detect different types of radiation, conducting interviews of chapter officials and local residents, and reviewing U. S. Bureau of Indian Affairs (BIA) lease information for the companies that developed the mines. The information was submitted to the EPA which will be using the federal Hazard Ranking System (HRS) to score each site and to determine the threat associated with actual or potential releases of hazardous substances. EPA uses the HRS to set priorities for further site evaluation and determine possible remedial action if the site is eligible for placement on the National Priorities List (NPL). The NPL identifies sites at which the EPA may conduct remedial response actions.

For further information about NNEPA, the Northern AUM Screening Assessment Report, or the King Tutt Aggregated Uranium Mine Sites, you may contact the following:

Mr. Steven B. Etsitty, Executive Director
Navajo Nation Environmental Protection Agency
Post Office Box 339
Window Rock, Arizona 86515
Telephone: 928-871-7692

Ms. Arlene C. Luther, Environmental Department Manager
Waste Regulatory Compliance Department
Navajo Nation Environmental Protection Agency
Post Office Box 339
Window Rock, Arizona 86515
Telephone: 928-871-7993

Ms. Diane J. Malone, Program Manager
Navajo Superfund Program
Post Office Box 2946
Window Rock, Arizona 86515
Telephone: 928-871-6859

NAVAJO ABANDONED MINE LANDS RECLAMATION PROGRAM

The Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) is a program under the Navajo Nation Division of Natural Resources. The purpose of the program is to fulfill the requirements of Public Law 95-87 "Surface Mining Control and Reclamation Act (SMCRA) of 1977." Title IV of Public Law 95-87 addresses abandoned mine reclamation.

Through SMCRA, reclamation funds for abandoned mine lands were set up to address land and water resources impacted by abandoned mines for which there were no responsible parties. Reclamation under this program can only be addressed to lands that have tribal trust status.

A trust fund was established in the U.S. Treasury as the Abandoned Mine Reclamation Fund to be administered by the Secretary of the Interior. All active coal mining operations deposit 35 cents per ton of coal produced into the fund, while underground mining operations deposit 15 cents per ton of coal produced. Fifty percent of the Abandoned Mine Lands Reclamation funds go to eligible tribes and states who can use it for administration, project development, and construction costs.

The NAMLRP was established in 1988 and since then has been reclaiming abandoned coal and non-coal mine sites within the boundaries of the Navajo Nation.

After the establishment of the NAMLRP, the following tasks were completed in order to understand the mining scenario throughout the Navajo Nation. NAMLRP completed an inventory, prioritized the abandoned mine sites, and made a determination as to which sites would be reclaimed. Many factors were taken into consideration, such as the need to protect public health, environmental problems, and overall safety for employees.

For further information about NAMLRP, you may contact the following:

Main Office : Madeline Roanhorse, Department Manager III
Navajo Abandoned Mine Lands Reclamation Program
Post Office Box 1875
Window Rock, Arizona 86515
Telephone: 928-871-6982

Field Office : Rose Grey, Program Manager II
Navajo Abandoned Mine Lands Reclamation Program
Post Office Box 3605
Shiprock, New Mexico
Telephone: 505-368-1220

Field Office : Ray Tsingine, Program Manager II
Navajo Abandoned Mine Lands Reclamation Program
Post Office Box 730
Tuba City, Arizona 86045
Telephone: 928-283-3187

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

The mission of the U. S. Environmental Protection Agency (EPA) is to protect human health and the environment. Since 1970, EPA has been working for a cleaner, healthier environment for the American people. EPA employs 18,000 people across the country, including our headquarters offices in Washington, DC, ten regional offices, and more than a dozen laboratories. EPA conducts environmental science, research, education and assessment efforts. EPA develops and enforces regulations, provides financial assistance, performs environmental research, and cleanup of contaminated sites.

EPA's Region 9 covers the southwestern United States (Arizona, California, Nevada, and Hawaii) and it works with 147 federally recognized tribes. EPA Region 9 has a Memorandum of Understanding with the Navajo Nation to work with the NNEPA in a government to government relationship. In response to concerns raised by the Navajo Nation during a 1993 Congressional hearing, the EPA Region 9 Superfund Program initiated an investigation aimed at assessing human exposure to radiation and heavy metals from abandoned uranium mines (AUMs). EPA conducted extensive field sampling of AUMs, water sources, and homes during the 1990s. In 2002, EPA developed the AUM Project Management Plan in partnership with the NNEPA to create a screening assessment mechanism, with close involvement by the NAMLRP.

The U.S. Army Corps of Engineers is producing a Geographic Information System (GIS) database and summary reports for EPA in support of AUM screening assessments on the Navajo Nation. The GIS database will identify the locations of all known uranium mines on the Navajo Nation and their proximity to residences, water sources, and surface water drainages. The reports will allow the project team to recommend Superfund removal actions or assessments to determine a site’s eligibility for Superfund removal actions and/or Superfund Site listing to the NNEPA. Based on the results of the mine screening study, EPA will consult with the Navajo Nation about the recommended follow-up investigations or cleanup responses requiring prompt attention. NNEPA, NAMLRP and EPA expect to complete the screening assessment phase by December 2006.

With respect to future work, EPA and NNEPA will coordinate closely with the NAMLRP to address directly or seek additional resources to address sites such as waste piles, unreclaimed mines, and mine contaminated water sources.

For further information about EPA or the Northern AUM Region Screening Report, you may contact the following:

Andrew Bain, Remedial Project Manager (SFD-8-2)
U. S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, California 94105
Telephone: 415-972-3167

ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION NORTHERN AUM REGION SCREENING ASSESSMENT REPORT

PURPOSE

The purpose of the Abandoned Uranium Mines and the Navajo Nation Project (AUM Project) is to conduct assessments identifying radiation sources, potential exposures, and to recommend methods to reduce exposure from AUMs on the Navajo Nation. There are more than 1,000 AUMs located throughout the Navajo Nation. Potential long-term exposure risks can persist even after the surface reclamation of AUM sites is completed. Therefore, an assessment of potential impacts to humans and the environment from the abandoned mines is needed.

The goal of the current phase of the AUM Project is to perform a screening assessment to prioritize Navajo AUM sites using existing, readily available data. The focus is to identify the areas with the highest apparent level of risk in order to recommend additional investigations by the appropriate Navajo or lead federal agency. Screening Assessment Reports and Geographic Information System (GIS) Data Packages will be developed for six regions of the Navajo Nation that experienced uranium mining. This Northern AUM Region Screening Assessment Report is the first of these reports, and describes the resulting Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) screening assessment conducted for the Northern AUM Region. A brief overview of the CERCLA process and a discussion of potential contaminants and exposure pathways related to AUMs is provided for background.

BACKGROUND

Widespread mining of uranium ore for Cold War weapons and nuclear energy production occurred on the Navajo Nation and throughout the Colorado Plateau. The Bureau of Indian Affairs (BIA) and the Navajo Nation negotiated mining leases with a number of private mining companies, who in turn processed the ore at their own facilities (mill sites) or sold the raw uranium ore to such facilities. Ultimately, the former United States Atomic Energy Commission (AEC) and its successor agency, the U.S. Department of Energy (DOE), acted as the sole market for all uranium ore.

It is probable that the mining activities led to dispersion of radioactive and heavy metal contaminated dusts, sediments, groundwater, and surface water to varying degrees, depending on site conditions, mining practices, and the amount and grade of material extracted. Since uranium is a naturally occurring element, the questions of how much dispersion or contamination occurred as a direct result of mining, who is at risk, and to what extent, are difficult to answer without a systematic review and analysis of all the AUM sites.

Congressional hearings about these concerns were conducted on November 4, 1993 (U.S. House of Representatives, 1993). During the hearings, the Navajo Nation presented testimony about the AUMs and requested assistance in determining if the mines posed a health risk to residents. The U.S. Environmental Protection Agency (EPA) presented testimony to describe its federal authority under CERCLA and how the EPA could assist the tribe. The DOE, the U.S. Department of Interior (DOI), the Navajo Nation Environmental Protection Agency (NNEPA), and the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) also participated in the hearings.

In response to the concerns raised by the Navajo Nation at the Congressional hearings, the EPA initiated the AUM Project in 1994. Between 1994 and 2000, under the authority of CERCLA, the EPA conducted field data collection efforts to determine the scope and impact of uranium mining on the Navajo Nation. These efforts were undertaken in cooperation with NNEPA, NAMLRP, and U.S. Army Corps of Engineers (USACE). Independently, NAMLRP has reclaimed a large quantity of AUMs using Surface Mining Control and Reclamation Act (SMCRA) funds. In addition, DOE and the Nuclear Regulatory Commission (NRC) have authority for investigating and addressing the former mill sites under the Uranium Mill Tailings Radiation Control Act (UMTRCA), a number of which are located in Navajo communities.

During the first phase of the AUM Project, EPA conducted extensive aerial radiological surveys, collected water samples, and surveyed homes to determine if they were constructed with radioactive materials from the mines. EPA prepared a draft Integrated Assessment for the King Tutt Mesa (EPA, 1999). EPA released a Project Atlas in 2000, providing an overview of the AUM Project data collected from 1994 to 2000, including the water and aerial radiation survey data.

In 2002, the Navajo Nation and EPA refocused the project approach, agreeing on the need to conduct a systematic review of existing data spanning the full spatial extent of the Navajo Nation to best address the CERCLA questions. NAMLRP provided EPA with mine site locations, representing the most accurate source of such data available. A GIS database was developed, concentrating on locational data about all known AUMs on the Navajo Nation. The resulting preliminary analysis will aid the agencies making CERCLA decisions and help plan for future use by the Navajo Nation.

The risk of human and ecological exposure on Navajo Lands occurs in the following three ways, which may present risk on the surface and subsurface: 1) Naturally occurring radioactive material (NORM), 2) the uranium milling activities, and 3) the AUM sites. CERCLA only addresses wastes resulting from man-made activities, such as mining, which includes waste piles. EPA has no authority under CERCLA with respect to naturally occurring ore. EPA is also excluded from addressing mill sites; DOE and NRC have the authority and responsibility for mill site reclamation under UMTRCA.

PROJECT APPROACH

This screening assessment was undertaken using existing data, EPA’s Hazard Ranking System (HRS) indicators, and applying the analytical capabilities of a GIS.

Key elements of this effort include identifying:

1. The location of the original sources (i.e., AUM)
2. The potential pathways for source exposures
3. The location of population indicators (structures) and water sources at risk for exposure

EPA’s Superfund program uses the HRS to evaluate whether a site is serious enough to be listed on the National Priorities List (NPL). Because there are over 1,000 known AUM sites on Navajo Lands, EPA needed to screen and prioritize all sites before applying the CERCLA process shown in Figure 1. EPA decided to use the geographic measures from the HRS to develop a basic screening model for the AUMs. This screening model includes the location of all known AUM sites as potential sources of exposure. Radiation and toxic metals that are released from an AUM site can travel through the air, through the soils, and through surface and groundwater. This model includes those pathways of potential contamination, and then evaluates the presence of structures as indicators of population at potential risk to exposure.

The EPA project team created an HRS-derived model to compare the individual AUM sites by distance from the human receptors. This report presents the results from the model in data tables and maps that were designed to identify and prioritize the AUM sites that might pose the highest threat to their surrounding communities.

The results in this report were not generated using a complete HRS model, nor does the screening assessment specify NPL site candidates. Based on this broad-based screening process, the EPA, NNEPA and NAMLRP will discuss next steps. One of the possible results of the analysis in this report might be to conduct a Preliminary Assessment (PA) or Site Inspection (SI) at a specific site identified as a priority via the scoring criteria and Navajo knowledge about the setting. Other decisions might entail referrals for EPA removal actions, referrals to other agencies, or a determination that no further action is necessary.

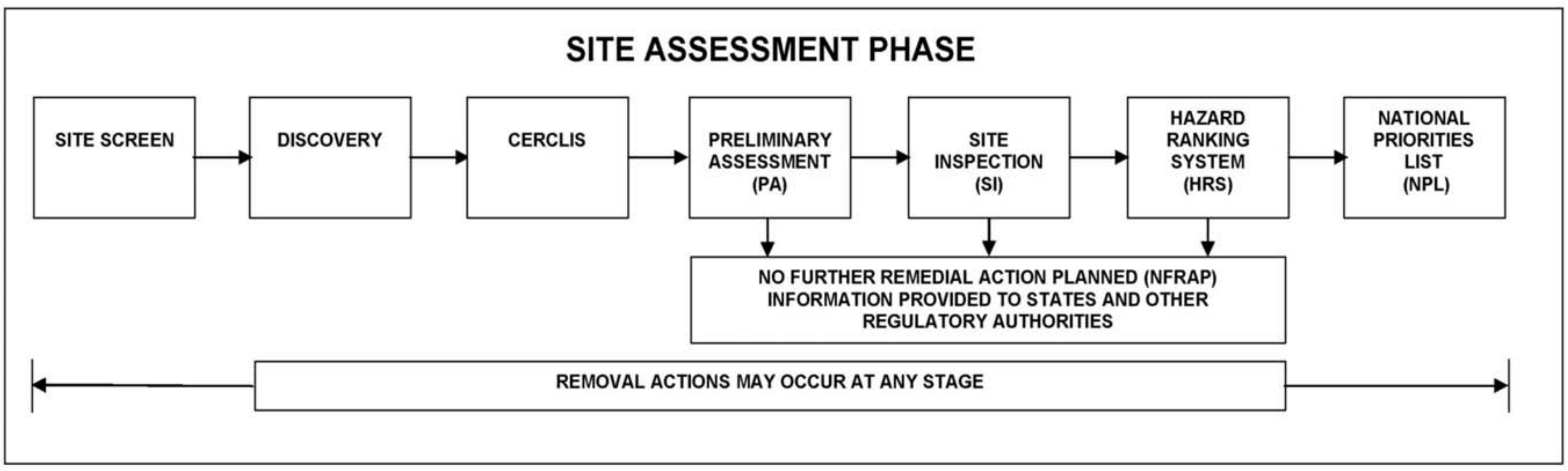


Figure 1. Superfund Process (modified after EPA, 1991).

The current phase of the AUM Project is limited to collecting existing and readily available data that can be used to: 1) identify potential radiation sources (AUMs), 2) screen for potential exposures, and 3) recommend follow-up actions. Table 1 provides the possible release mechanisms, pathways, exposure routes, and human and ecological receptors (targets) associated with AUMs.

PRIMARY SOURCES	RELEASE MECHANISM	PATHWAYS	EXPOSURE ROUTE	RECEPTOR		
				Area Resident	Livestock and Terrestrial Wildlife	Aquatic Wildlife
Uranium Mines and Natural Ore Bodies	Infiltration / Percolation	Ground Water	Direct Contact	✔	✔	✔
	Storm water Runoff	Surface Water and Sediments	Direct Contact	✔	✔	✔
	Particles/Dust	Soil Exposure	Inhalation	✔	✔	
			Direct Contact	✔	✔	
	Particles/Dust	Air	Inhalation	✔	✔	
			Direct Contact	✔	✔	

Table 1. Possible pathways, exposure routes, and human and ecological receptors (after EPA, 1991).

CONTAMINANTS AND EXPOSURE PATHWAYS

Although exposure to uranium in natural settings may be limited, mining activities often result in increased exposure risks. This includes both direct and indirect exposures that can occur via multiple pathways. Mining activities disturbs mineralization that can affect exposures. Activities such as removing overburden, tunneling, and transporting ore can expose previously protected mineral deposits to accelerated oxidation and increase their mobility through the environment. These activities can also change groundwater and surface water flow, which can lead to the release of hazardous materials into the environment (EPA, 2000a).

Radioactive decay of the parent Uranium^{238} material produces a series of new elements and radiation, including radium and radon, alpha and beta particles, and gamma radiation. Because of the slow rate of decay, the total amount of natural uranium in the earth stays almost the same, but it can be moved from place to place through natural processes or by human activities. When rocks are eroded by water or wind, uranium minerals become a part of the soil. When it rains, the soil containing uranium minerals can be transported via leached material and deposited into rivers and lakes. Mining, milling, and other human activities can also move uranium around natural environments. Uranium ore concentrations and associated radioactivity varies widely at mining areas and geological formations across the Navajo Nation. Other potential contaminants of concern include arsenic and lead. EPA is evaluating the likelihood for offsite migration of contaminants due to historic mining activities, but not the natural occurrences (EPA, 2004a).

NORTHERN AUM REGION

The Northern AUM Region was an important center of uranium mining on the Navajo Nation. The Northern AUM Region is located in the northeastern portion of the Navajo Nation, straddling three counties and three states: Apache County, Arizona; San Juan County, New Mexico; and San Juan County, Utah. Figure 2 shows the location of the Northern AUM Region within the Navajo Nation. The Northern AUM Region is comprised of 11 Chapters: Aneth, Beclabito, Cove, Lukachukai, Red Mesa, Red Valley, Round Rock, Sanostee, Shiprock, Sweetwater, and Teec Nos Pos.

The Northern AUM Region covers approximately 1,926,031 acres (3,009 square miles) in the hilly, high-altitude plains of the Navajo Nation. The region is generally sparsely populated. The 2000 Census estimated the total resident population for the entire region at 22,358. Appendix A - Structures describes the general physical and population characteristics for each of the chapters comprising the Northern AUM Region.

Most uranium mining activities on the Navajo Nation occurred between the 1940's and 1960's in support of U.S. Government defense programs. Mining activities ended in 1968, but the legacy of AUMs, widely distributed wastes, and collateral environmental, cultural, and economic impacts continues (Sowder, 2001). There are 285 mapped AUMs (including 2 transfer stations) and 870 mapped mining features associated with the AUMs in the Northern AUM Region. The mining features are comprised of Adit or Incline Portals (417), Vertical Shafts (9), Rim Strips and Pits (303), Prospects (136), Waste Piles (4), and 1 drill hole (see Appendix A, page A-4).

METHODOLOGY

The methodology followed these general steps to develop this Northern AUM Region Screening Assessment Report:

- Develop a CERCLA HRS-derived model to assess and compare AUM priorities on the Navajo Nation
- Acquire data inputs for the HRS model and automate into a GIS database
- Apply the HRS screening criteria using GIS analysis tools
- Generate a scoring list for each pathway and a composite scoring list

HRS-DERIVED MODEL

The EPA Superfund Site Assessment and Technical Support Team selected a subset of HRS criteria to develop screening scores for the AUMs. The purpose of this analytical model is to prioritize Navajo AUM sites using readily available data. The level of detail in this study is not as robust as required for remedy decision making, since the purpose of the screening model is not to determine actual risks, but rather to identify priority areas for future investigation. The EPA team considered probable Navajo exposure pathways as the basis for the model. The large area involved in the assessment falls beyond the normal scope for HRS, so a custom model was developed to best fit these unique circumstances.

Due to the unique nature of the task, the EPA team considered the probable Navajo exposure pathways and used 40 CFR 300, Federal Register Notice, HRS Final Rule, December 1990 (EPA, 1990) as the basis for the HRS-derived model. Given the EPA's experience collecting available and pertinent Navajo Nation environmental data and the large land area under consideration, the EPA decided to conservatively address all known release points (i.e., uranium mines, features, and waste piles), all known drainages downstream from AUMs, all known water wells (domestic, agricultural, and municipal), and all structures. However, sensitive environments, such as endangered species, wetlands, and cultural data, were not readily available with enough locational specificity (compatible with GIS format) to input into the model. The inclusion of HRS criteria for sensitive environments would be recommended during future site-specific characterization activities, where the Navajo Nation would also be able to protect sensitive information with internal controls.

Consideration was given to the general fate and transport of radionuclides, as well as probable Navajo Nation exposure assessment scenarios. For example, the scenario of a rural homestead adjacent to an unfenced AUM site where the residents spend considerable waking hours outdoors with access to a nearby surface water source was considered. As a conservative assumption, it was presumed that all water sources may be used for human consumption and that uranium ore is mobile in dissolved media. For the two water pathways, a simple numeric progression was chosen. A high bias was used in weighting the soil and air pathway for close proximity (within 200 feet) due to the rural, agrarian lifestyle of the residents. A low bias was used in weighting the soil and air pathway for more distant proximity (>200 feet) due to strong winds associated with dispersion effects and the difficulty in attributing sources. The HRS-derived model developed for the AUM Project for each of the pathways is listed below.

Air Pathway – 200 feet, 1,320 feet (1/4 mile), and 1 mile.

- For structures within 200 feet of an AUM site, assign 100 points per structure,
- For structures that exist between 200 feet and 1,320 feet, assign 25 points per structure,
- For structures that exist between 1,320 feet and 1 mile, assign 10 points per structure, and
- For structures beyond 1 mile, assign 0 points.

Soil Exposure - 200 feet, 1,320 feet, and 1 mile.

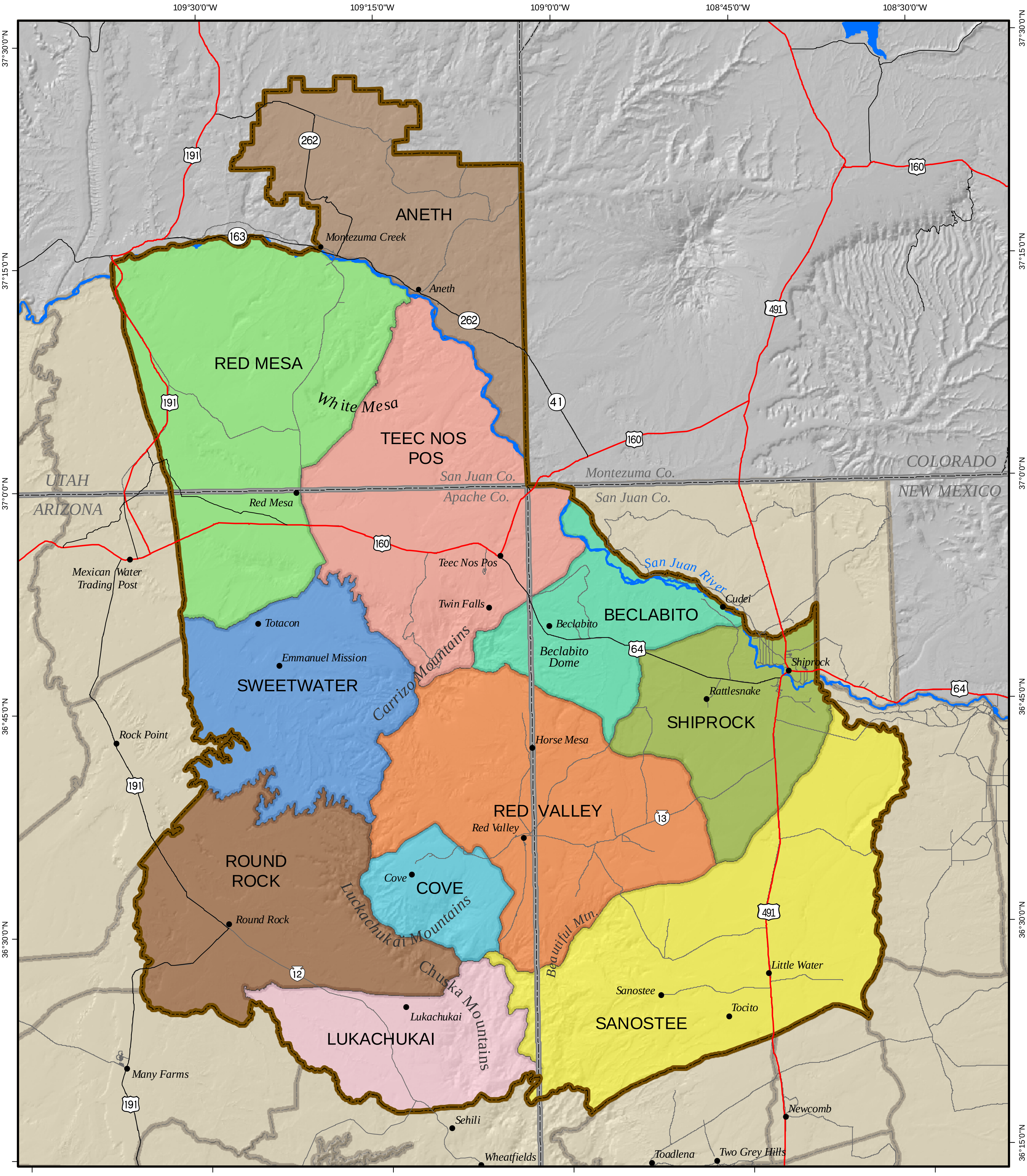
- For structures within 200 feet of an AUM site, assign 100 points per structure,
- For structures that exist between 200 feet and 1,320 feet, assign 25 points per structure,
- For structures that exist between 1,320 feet and 1 mile, assign 10 points per structure, and
- For structures beyond 1 mile, assign 0 points.

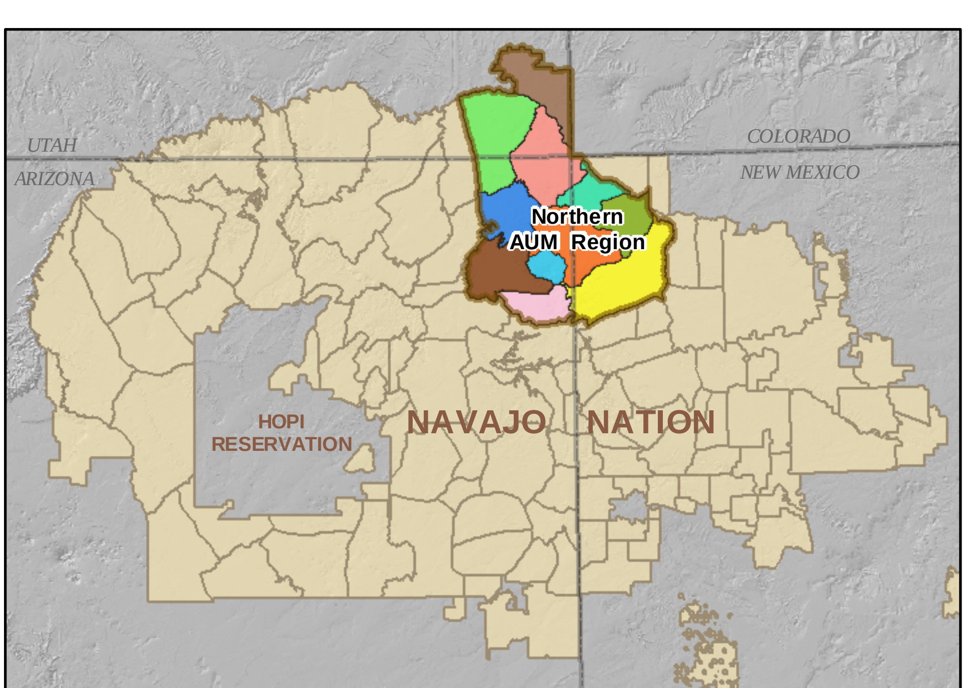
Groundwater Pathway - 1,320 feet, 1 mile, and 4 miles.

- For wells within 1,320 feet of an AUM site, assign 100 points per well,
- For wells that exist between 1,320 feet and 1 mile, assign 50 points per well,
- For wells that exist between 1 mile and 4 miles, assign 10 points per well, and
- For wells beyond 4 miles, assign 0 points.

Surface Water Pathway - 1 mile, 4 miles, and 15 miles.

- For perennial or intermittent surface water within one mile of an AUM site, assign 100 points,
- For perennial or intermittent surface water that exist between 1 mile and 4 miles, assign 50 points,
- For perennial or intermittent surface water that exists between 4 miles and within 15 miles, assign 10 points,
- For perennial or intermittent surface water beyond 15 miles, assign 0 points.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

NORTHERN AUM REGION

0 20 Miles

Map Scale 1:500,000

Legend

- Northern AUM Region
- Chapter
- Highway
- Paved Road

Figure 2. Northern AUM Region Location on the Navajo Nation.

DATA

The following data were identified as required to perform the HRS-derived scoring algorithm for the AUM Project:

AUM sites - Locations for the potential radioactive material sources (AUMs) were obtained from several sources, including: NAMLRP Reclamation Project Area boundaries, various uranium mining history reports by William Chenoweth. Utah Geological Survey Mineral Database, Scarborough (1981), McLemore (2002), U.S. Department of Energy aerial radiation surveys, U.S. Geological Survey (USGS) digital orthophoto quarter quadrangles (DOQQ) , and USGS 7.5' topographic maps. AUM boundary polygons were generated for each of the identified AUMs, unreclaimed waste piles, and unreclaimed mine features. These polygons were used to represent the surface extents and locations of AUMs. Polygon boundaries for AUMs with underground workings were generated.

Structures - Structures are buildings that are residences or some other type of building where people may live, work, or gather. Locations of structures within 1 mile of AUMs were interpreted from DOQQs, USGS 7.5' topographic maps, and utility meter locations. Structures are the target for the air and soil pathways.

Wells - A wells dataset acquired from the Navajo Water Resources Department and augmented using data from the Arizona Department of Water Resources, New Mexico Office of the State Engineer, Utah Department of Water Resources, National Hydrography Database, Geographic Names Information System, U.S. Army Corps of Engineers water sample locations, USGS Ground-water Site Investigations Database, and USGS DRGs and DOQQs was used as the target for the ground-water pathway.

Drainages - The USGS/EPA National Hydrography Dataset (NHD), along with DOQQs and DRGS, were used to identify perennial and intermittent drainages down-stream from AUMs.

Appendix A presents descriptions of the data sources, methods for data collection and automation into the GIS database, uses of the data, and data limitations. Appendix A also provides examples of maps that were developed from the GIS datasets.

RESULTS

This section presents the results of the HRS-derived screening model for AUM sites located within the Northern AUM Region. As previously stated, these scores are not intended to indicate actual risk, but will be used to assist with establishing priorities for future investigations.

A summary table for the total groundwater pathway scores for each AUM and a summary table for the soil pathway and air pathway scores for each AUM were generated and are presented as Table 2 and Table 3, respectively. A separate summary table for the surface water pathway was not prepared, as explained below. The pathway summary tables include a MAP-ID, which is a sequential number to facilitate map labeling and is generally assigned so that MAP-ID increases from north to south and west to east. The MAP-ID numbers are unique to this report and do not correspond with MAP-ID numbers used in the earlier Red Valley Chapter Screening Assessment Report pilot study (EPA, 2004b). The tables include the name of the Chapter the AUM is located within. Each AUM was assigned a mine name or identifier using the following naming hierarchy: the mine name (if available), or the NAMLRP reclamation project number, or finally, the NAMLRP feature number. The groundwater pathway summary table presents the counts of wells that fall within the 1/4 mile, 1 mile, and 4 mile buffers and the total number of wells within 4 miles of each AUM (inclusive of the surface extent and underground workings for the AUM). The scores for each buffer zone were tabulated and presented for each AUM in Table 2.

The soil and air pathway summary table presents the counts of structures that fall within the 200 foot, 1/4 mile, and 1 mile buffers and the total number of structures within 1 mile of the surface extent of each AUM. The scores for each buffer zone are tabulated and presented for each AUM. Since the air and soil pathway criteria are the same, the total score results for the soil pathway and air pathway are both shown in Table 3.

A summary table entitled "Combined Pathway Score" (Table 4) sums the total scores of each pathway for each AUM site to establish total scores. Maps showing the locations of the scored AUMs are presented at the end of this section.

SURFACE WATER PATHWAY

Water erosion is the process by which soil particles are detached and transported from their original location. Sedimentation is the by-product of erosion, whereby eroded particles are deposited at a location different from their origin. Erosion is a concern for AUMs because of the mine wastes. Major sources of erosion and sediment loadings at mining sites include waste rock and overburden piles, haul and access roads, exploration areas, and reclamation areas. Hazardous constituents (e.g., radionuclides and metals) associated with discharges from mining operations may be found at elevated levels in sediments (EPA, 2000a).

Evaluation of the surface water pathway using the modified HRS required the location of the AUM sites and distance to perennial and intermittent streams or drainages. The HRS criteria used to evaluate the surface water pathway were:

- For perennial or intermittent surface water within one mile of an AUM site, assign 100 points,
- For perennial or intermittent surface water between 1 mile and 4 miles, assign 50 points,
- For perennial or intermittent surface water between 4 miles and 15 miles, assign 10 points,
- If no perennial or intermittent surface water exists within 15 miles, assign 0 points.

All of the AUM sites within the Northern AUM Region were located within 1 mile, 4 miles, and 15 miles of an intermittent stream or drainage (see Figure 3). All AUM sites scored 160 (score = 100+50+10). For this reason, a table was not developed for the Surface Water Pathway score results.

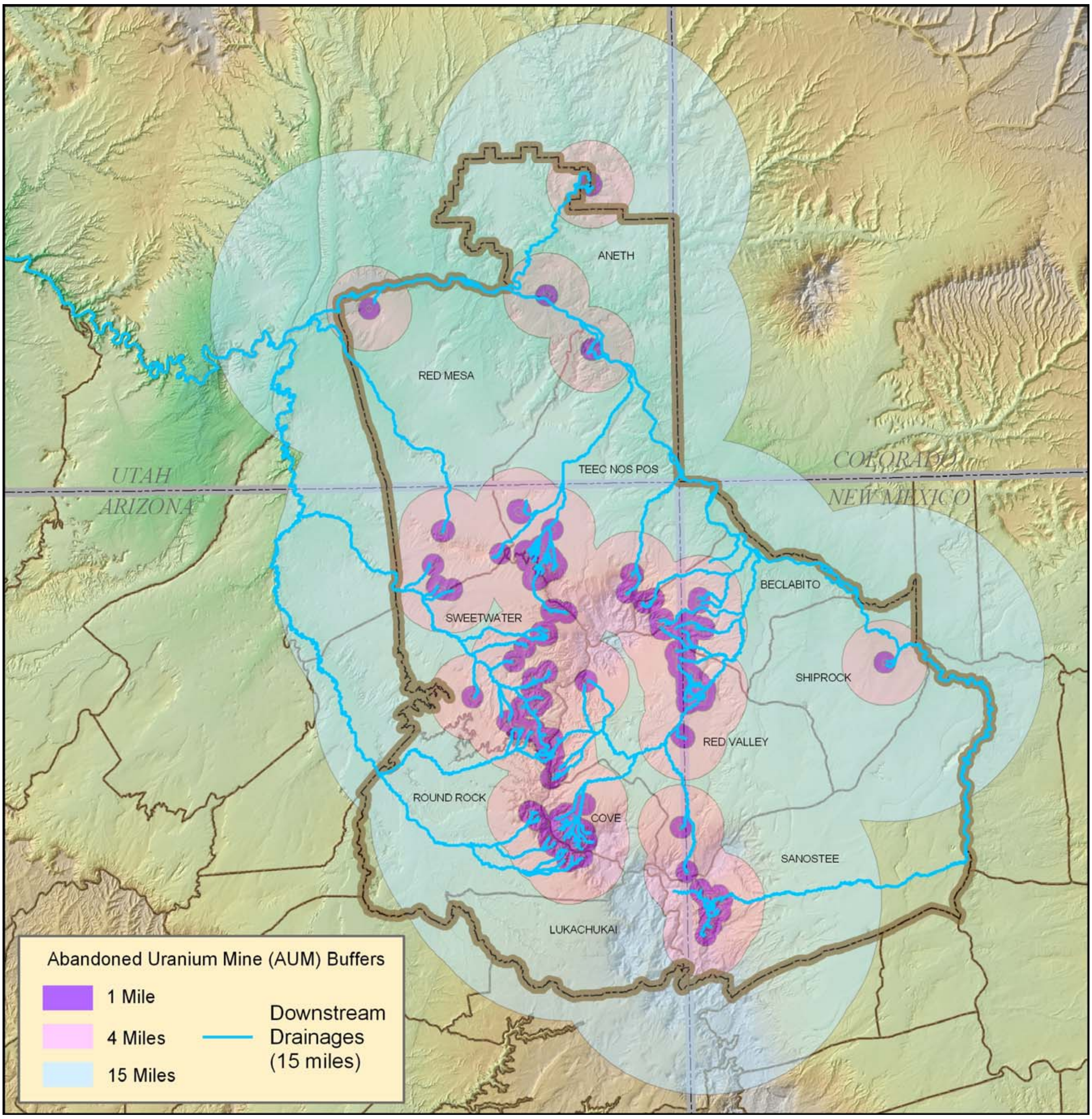


Figure 3. Surface Water Drainages Downstream from AUM Sites.

Figure 3 above shows that drainages intersect AUM site buffers at 1 mile, 4 miles, and 15 miles in all cases within the Northern AUM Region. This resulted in the same score for all AUM sites.

GROUNDWATER PATHWAY

Mining operations can affect groundwater quality in several ways. The most obvious occurs in underground workings, which can provide a direct conduit to aquifers. Groundwater quality is also affected when waters infiltrate through surface materials (e.g., mine debris piles) into groundwater. Contamination can also occur when there is a hydraulic connection between surface and groundwater. Any of these situations can cause elevated contaminant levels in groundwater. In addition, contaminated groundwater may discharge to surface water down-gradient of the AUM site, as contributions to base flow in a stream channel or spring (EPA, 2000a).

Evaluation of the groundwater pathway using the HRS-derived criteria required the location of the AUM sites and distance to wells. For the groundwater pathway, underground workings of the AUMs were mapped and the total area of the surface and underground extent of the AUM was used to generate the buffers. The HRS criteria used to evaluate the groundwater pathway were:

- For wells within 1,320 feet of an AUM site, assign 100 points per well,
- For wells between 1,320 feet and 1 mile, assign 50 points per well,
- For wells between 1 mile and 4 miles, assign 10 points per well, and
- If no well exists within 4 miles, assign 0 points.

Results for the groundwater pathway assessment are shown in Table 2. The table was sorted by MAP-ID number. The highest groundwater pathway score is 920 and is located at Plot 13 in the Sweetwater Chapter (MAP-ID #51). The total groundwater pathway score for this site is comprised of 8 wells within 1/4 mile of the AUM, 0 wells in the 1/4 mile to 1 mile buffer, and 12 wells in the 1 mile to 4 mile buffer.

Table 2. Groundwater Pathway Score.

MAP-ID	Chapter	Mine Name / Identifier	1/4 Mile Wells Count	1 Mile Wells Count	4 Mile Wells Count	Total Wells Count	1/4 Mile Score	1 Mile Score	4 Mile Score	Total Groundwater Score
1	Aneth	Pete 6 & 7	0	0	12	12	0	0	120	120
2	Red Mesa	NA-0238	0	0	36	36	0	0	360	360
3	Aneth	Montezuma Creek Mine	0	1	34	35	0	50	340	390
4	Teec Nos Pos	Aneth 1	0	0	32	32	0	0	320	320
5	Red Mesa	Tom Morgan 1	0	0	4	4	0	0	40	40
6	Red Mesa	Barton 3	0	0	5	5	0	0	50	50
7	Red Mesa	John Lee Benally	0	0	12	12	0	0	120	120
8	Red Mesa	Phillip Dee 1	0	1	13	14	0	50	130	180
9	Red Mesa	NA-0509A	1	0	13	14	100	0	130	230
10	Sweetwater	Johnny McCoy 1	0	8	7	15	0	400	70	470
11	Teec Nos Pos	John Kee 4	0	2	14	16	0	100	140	240
12	Teec Nos Pos	Capitan Benally No. 4A	0	0	11	11	0	0	110	110
13	Red Mesa	Brodie 1	0	0	15	15	0	0	150	150
14	Teec Nos Pos	Block K	0	1	19	20	0	50	190	240
15	Teec Nos Pos	NA-0928	0	2	17	19	0	100	170	270
16	Teec Nos Pos	Silentman 1	0	1	18	19	0	50	180	230
17	Teec Nos Pos	McKenzie 3	1	1	20	22	100	50	200	350
18	Teec Nos Pos	Plot 2	1	1	20	22	100	50	200	350
19	Teec Nos Pos	NA-0904	1	2	17	20	100	100	170	370
20	Teec Nos Pos	Plot 1	1	2	19	22	100	100	190	390
22	Teec Nos Pos	Plot 4	0	2	20	22	0	100	200	300
22	Teec Nos Pos	Plot 3	0	1	21	22	0	50	210	260
23	Teec Nos Pos	Plot 5	0	2	19	21	0	100	190	290
24	Sweetwater	NA-0926	0	3	16	19	0	150	160	310
25	Sweetwater	NA-0924	0	2	19	21	0	100	190	290
26	Teec Nos Pos	Hoskie Henry	0	0	19	19	0	0	190	190
27	Teec Nos Pos	Pope 1	0	1	18	19	0	50	180	230
28	Teec Nos Pos	Plot 6	0	1	19	20	0	50	190	240
29	Teec Nos Pos	Hoskie Henry	0	0	20	20	0	0	200	200
30	Teec Nos Pos	NA-0919B	0	1	18	19	0	50	180	230
31	Teec Nos Pos	NA-0919A	0	1	18	19	0	50	180	230
32	Teec Nos Pos	Plot 7	0	1	19	20	0	50	190	240
33	Teec Nos Pos	Tse079	0	1	19	20	0	50	190	240
34	Teec Nos Pos	Plot 8	0	1	19	20	0	50	190	240
35	Teec Nos Pos	Black Rock Point Mines	0	1	19	20	0	50	190	240
36	Teec Nos Pos	NA-0917A	0	1	19	20	0	50	190	240
37	Teec Nos Pos	Plot 9	0	1	19	20	0	50	190	240
38	Teec Nos Pos	Jimmie Bileen 1	0	1	19	20	0	50	190	240
39	Teec Nos Pos	Sandy K	0	1	19	20	0	50	190	240
40	Teec Nos Pos	Plot 10	1	1	18	20	100	50	180	330
41	Teec Nos Pos	Plot 11	0	2	18	20	0	100	180	280
42	Sweetwater	North Martin	0	8	12	20	0	400	120	520
43	Sweetwater	Grover Cleveland 1	0	9	11	20	0	450	110	560
44	Sweetwater	Martin Mine	2	7	11	20	200	350	110	660
45	Sweetwater	Rattlesnake No. 8	4	5	11	20	400	250	110	760
46	Sweetwater	Tsosie 1	0	10	10	20	0	500	100	600
47	Sweetwater	George Simpson 1 Incline	3	6	11	20	300	300	110	710
48	Sweetwater	Saytah	3	5	12	20	300	250	120	670
49	Sweetwater	Carson	7	1	12	20	700	50	120	870
50	Sweetwater	AEC Plot 3	4	5	11	20	400	250	110	760
51	Sweetwater	Plot 13	8	0	12	20	800	0	120	920
52	Sweetwater	Last Chance	3	6	10	19	300	300	100	700
53	Sweetwater	Melvin Benally 1	0	0	14	14	0	0	140	140
54	Sweetwater	Saytah Canyon	0	0	14	14	0	0	140	140
55	Sweetwater	CBW-MC Mine	0	0	16	16	0	0	160	160
56	Sweetwater	Saytah Canyon	0	0	16	16	0	0	160	160
57	Sweetwater	Benally No. 3	0	0	12	12	0	0	120	120
58	Sweetwater	School Boy	0	1	5	6	0	50	50	100
59	Teec Nos Pos	Rattlesnake No. 1	0	0	18	18	0	0	180	180
60	Teec Nos Pos	Bettie No. 1	0	0	5	5	0	0	50	50
61	Beclabito	Zona No. 1	0	1	3	4	0	50	30	80
62	Beclabito	Ruben No. 1	0	1	3	4	0	50	30	80
63	Beclabito	Jim Lee No. 1, Richard King No. 1	1	0	4	5	100	0	40	140
64	Beclabito	Todakonzie No. 1	0	1	4	5	0	50	40	90
65	Beclabito	NA-0424	2	1	6	9	200	50	60	310
66	Beclabito	NA-0420	0	3	6	9	0	150	60	210
67	Beclabito	Harvey Begay 3	0	1	9	10	0	50	90	140
68	Red Valley	Toni Tuc No. 1 Mine	0	0	10	10	0	0	100	100
69	Beclabito	Upper Red Canyon Mine	0	0	10	10	0	0	100	100
70	Beclabito	King 6	0	0	11	11	0	0	110	110
71	Beclabito	Barton & Begay	0	0	10	10	0	0	100	100
72	Beclabito	Barton & Begay	0	2	8	10	0	100	80	180
73	Beclabito	Rocky Flats 1	0	1	9	10	0	50	90	140
74	Beclabito	Bec064	0	0	11	11	0	0	110	110
75	Beclabito	Canyon 1	0	0	11	11	0	0	110	110
76	Beclabito	Bec068	0	0	11	11	0	0	110	110
77	Beclabito	John John 1	0	0	14	14	0	0	140	140
78	Beclabito	John John 1	0	0	13	13	0	0	130	130
79	Beclabito	Bec054	0	0	13	13	0	0	130	130
80	Beclabito	King 2	0	0	13	13	0	0	130	130
81	Beclabito	Rocky Flats 2	0	0	13	13	0	0	130	130
82	Beclabito	Barton and Lee	0	0	13	13	0	0	130	130
83	Beclabito	Barton and Lee	0	1	13	14	0	50	130	180
84	Beclabito	Barton and Lee	0	1	13	14	0	50	130	180
85	Beclabito	Barton and Lee	0	1	12	13	0	50	120	170
86	Sweetwater	Chester Mud 1	0	0	1	1	0	0	10	10
87	Sweetwater	Eurida Mine	0	0	2	2	0	0	20	20
88	Sweetwater	Plot 14	0	0	2	2	0	0	20	20
89	Sweetwater	East Workings	0	0	1	1	0	0	10	10
90	Sweetwater	NA-0505B	0	0	1	1	0	0	10	10
91	Sweetwater	Plot 16	0	0	1	1	0	0	10	10
92	Sweetwater	Plot 15	0	0	1	1	0	0	10	10
93	Sweetwater	NA-0504	0	0	2	2	0	0	20	20
94	Sweetwater	Chimney No. 1	0	0	1	1	0	0	10	10
95	Sweetwater	Sunnyside	0	0	0	0	0	0	0	0
96	Sweetwater	Sunnyside	0	0	0	0	0	0	0	0
97	Sweetwater	Swt018	0	0	0	0	0	0	0	0

Table 2. Groundwater Pathway Score (continued)

MAP-ID	Chapter	Mine Name / Identifier	1/4 Mile Wells Count	1 Mile Wells Count	4 Mile Wells Count	Total Wells Count	1/4 Mile Score	1 Mile Score	4 Mile Score	Total Groundwater Score
98	Red Valley	Tohe Thlany Begay Mine	0	0	0	0	0	0	0	0
99	Red Valley	Cov192	0	0	0	0	0	0	0	0
100	Sweetwater	AEC Plot B	0	0	0	0	0	0	0	0
101	Sweetwater	Mildred 1	0	0	0	0	0	0	0	0
102	Sweetwater	NA-0512	0	0	0	0	0	0	0	0
103	Sweetwater	AEC Plot D	0	0	0	0	0	0	0	0
104	Sweetwater	Sheepskin Mesa	0	0	0	0	0	0	0	0
105	Sweetwater	Tree Mesa	0	0	0	0	0	0	0	0
106	Sweetwater	Swt003	0	0	0	0	0	0	0	0
107	Sweetwater	NA-0510	0	0	0	0	0	0	0	0
108	Sweetwater	Kinusta Mesa	0	0	0	0	0	0	0	0
109	Sweetwater	NA-0511	0	0	0	0	0	0	0	0
110	Sweetwater	Cove Mesa Mines (Cato Sells)	0	0	1	1	0	0	10	10
111	Red Valley	Cove Mesa Mines (Cato Sells)	0	0	1	1	0	0	10	10
112	Red Valley	Cove Mesa Mines (Cato Sells)	0	0	1	1	0	0	10	10
113	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
114	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
115	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
116	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
117	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
118	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
119	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
120	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
121	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	1	1	0	0	10	10
122	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
123	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
124	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
125	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
126	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
127	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
128	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	2	2	0	0	20	20
129	Red Valley	Cottonwood Butte Mine	0	1	14	15	0	50	140	190
130	Red Valley	Syracuse Mine	0	0	17	17	0	0	170	170
131	Red Valley	Hazel Mine	0	0	18	18	0	0	180	180
132	Red Valley	NA-0410	0	1	16	17	0	50	160	210
133	Red Valley	North Star Mine	0	1	17	18	0	50	170	220
134	Red Valley	Lone Star Mine	0	1	16	17	0	50	160	210
135	Red Valley	Valley View Mine	0	0	16	16	0	0	160	160
136	Red Valley	White Cap Mine	0	0	17	17	0	0	170	170
137	Red Valley	Upper Canyon Mine	0	2	16	18	0	100	160	260
138	Red Valley	Leroy Mine	0	2	16	18	0	100	160	260
139	Red Valley	Lower Canyon Mine	0	2	15	17	0	100	150	250
140	Red Valley	NA-0405	0	2	15	17	0	100	150	250
141	Red Valley	Oak Springs Mine (Gravel Cap)	2	1	16	19	200	50	160	410
142	Red Valley	Oak Springs Mine	2	1	16	19	200	50	160	410
143	Red Valley	Oak238	0	2	17	19	0	100	170	270
144	Red Valley	VCA Plot 7 Mines	0	2	17	19	0	100	170	270
145	Red Valley	VCA Plot 7 Mines	0	2	17	19	0	100	170	270
146	Red Valley	Franks Point Mine	0	0	20	20	0	0	200	200
147	Red Valley	Upper Salt Rock Canyon Mine	0	1	19	20	0	50	190	240
148	Red Valley	VCA Plot 7 Mines	0	0	19	19	0	0	190	190
149	Red Valley	Lower Salt Rock Canyon Mine	0	0	19	19	0	0	190	190
150	Red Valley	Williams Point Mine	0	2	18	20	0	100	180	280
151	Red Valley	Salt Canyon Mines	0	1	18	19	0	50	180	230
152	Red Valley	Salt Canyon Mines	0	1	18	19	0	50	180	230
153	Red Valley	NA-0814	0	3	17	20	0	150	170	320
154	Red Valley	Lookout Point Mines	0	2	18	20	0	100	180	280
155	Red Valley	Lookout Point Incline Mine	0	3	17	20	0	150	170	320
156	Red Valley	Stripped Area 1 of VCA Plot 3	0	3	17	20	0	150	170	320
157	Red Valley	VCA Plot 3	0	0	18	18	0	0	180	180
158	Red Valley	Shadyside No. 2 Mine	0	0	18	18	0	0	180	180
159	Red Valley	Shadyside No. 1 Mine	0	0	19	19	0	0	190	190
160	Red Valley	VCA Plot 3	0	0	19	19	0	0	190	190
161	Red Valley	Begay No. 2 Mine	0	0	19	19	0	0	190	190
162	Red Valley	Begay Incline	0	0	19	19	0	0	190	190
163	Red Valley	Stripped Area 2 of VCA Plot 3	0	3	17	20	0	150	170	320
164	Red Valley	Shadyside Incline	0	2	17	19	0	100	170	270
165	Red Valley	NA-0809	0	4	16	20	0	200	160	360
166	Red Valley	NA-0822	0	5	16	21	0	250	160	410
167	Red Valley	Nelson Point Mine	0	4	17	21	0	200	170	370
168	Red Valley	Tent Mine	0	4	17	21	0	200	170	370
169	Red Valley	Oak143, Oak146	0	3	17	20	0	150	170	320
170	Red Valley	NA-0806	0	5	15	20	0	250	150	400
171	Red Valley	NA-0821	0	5	15	20	0	250	150	400
172	Red Valley	Oak156	0	5	15	20	0	250	150	400
173	Red Valley	Stripped Area 3 of VCA Plot 3	0	5	15	20	0	250	150	400
174	Red Valley	NA-0824	1	0	18	19	100	0	180	280
175	Red Valley	Junction Mine	0	1	18	19	0	50	180	230
176	Red Valley	King Tutt Point Mines	0	2	16	18	0	100	160	260
177	Red Valley	Carrizo No. 1 Mine	0	0	18	18	0	0	180	180
178	Red Valley	Begay No. 1 Mine	0	0	18	18	0	0	180	180
179	Red Valley	King Tutt No. 1 Mine	0	1	17	18	0	50	170	220
180	Red Valley	Red Wash Point Mine	0	1	17	18	0	50	170	220
181	Red Valley	Oak124, Oak125	0	0	18	18	0	0	180	180
182	Red Valley	Begay No. 1 Mine	0	1	17	18	0	50	170	220
183	Red Valley	Alongo Mines	0	1	18	19	0	50	180	230
184	Red Valley	Red Rock Mine	0	3	15	18	0	150	150	300
185	Red Valley	NA-0828	0	2	16	18	0	100	160	260
186	Red Valley	Oak230	0	2	16	18	0	100	160	260
187	Red Valley	Red Wash Mine (Leroy Pettigrew)	0	2	16	18	0	100	160	260
188	Red Valley	Red Wash Mine (Hosteen S. Begay)	0	0	17	17	0	0	170	170
189	Red Valley	Upper Red Wash Mine	0	0	14	14	0	0	140	140
190	Red Valley	Upper Red Wash Mine	0	0	14	14	0	0	140	140
191	Shiprock	Climax Transfer Station	0	0	7	7	0	0	70	70
192	Red Valley	East Mesa Mines	0	1	7	8	0	50	70	120
194	Cove	West Mesa Mine	0	0	9	9	0	0	90	90
194	Red Valley	Cove Transfer Station	2	0	14	16	200	0	140	340

Table 2. Groundwater Pathway Score (continued)

MAP-ID	Chapter	Mine Name / Identifier	1/4 Mile Wells Count	1 Mile Wells Count	4 Mile Wells Count	Total Wells Count	1/4 Mile Score	1 Mile Score	4 Mile Score	Total Groundwater Score
195	Round Rock	Mexican Cry Mine	0	0	3	3	0	0	30	30
196	Round Rock	Mexican Cry Mine	0	0	3	3	0	0	30	30
197	Round Rock	Hall Mine	0	0	3	3	0	0	30	30
198	Round Rock	Cov198	0	0	3	3	0	0	30	30
199	Round Rock	Nakai Chee Begay Mine	0	0	3	3	0	0	30	30
200	Cove	Cato No. 2	0	0	13	13	0	0	130	130
201	Cove	Cato No. 1 Pit	0	0	13	13	0	0	130	130
202	Cove	Frank Jr. Mine	0	0	12	12	0	0	120	120
203	Cove	NA-0319	0	0	12	12	0	0	120	120
204	Cove	Mesa VI Mine	0	1	11	12	0	50	110	160
205	Cove	NA-0319	0	1	11	12	0	50	110	160
206	Cove	Mesa V Adit	0	0	12	12	0	0	120	120
207	Cove	Mesa V Incline	0	0	12	12	0	0	120	120
208	Cove	Mesa V Mine	0	1	11	12	0	50	110	160
209	Cove	Mesa V Mine	0	1	11	12	0	50	110	160
210	Cove	NA-0318	0	0	12	12	0	0	120	120
211	Cove	Cov087	0	1	11	12	0	50	110	160
212	Cove	Mesa IV 1/2 Mine	0	1	11	12	0	50	110	160
213	Cove	North Portal, Frank No. 1 Mine	0	1	11	12	0	50	110	160
214	Cove	East Portal, Frank No. 1 Mine	0	1	11	12	0	50	110	160
215	Cove	Frank No. 2	0	1	10	11	0	50	100	150
216	Cove	South Portal, Frank No. 1 Mine	0	1	8	9	0	50	80	130
217	Cove	NA-0316	0	1	8	9	0	50	80	130
218	Cove	Cov068	0	0	12	12	0	0	120	120
219	Cove	Mesa IV, Mine No. 2	0	0	12	12	0	0	120	120
220	Cove	Mesa IV, Mine No. 3	0	0	12	12	0	0	120	120
221	Cove	Mesa IV, Mine No. 1	0	0	12	12	0	0	120	120
222	Cove	Mesa II Pit	0	0	12	12	0	0	120	120
223	Cove	Mesa IV 1/4 Mine	0	1	8	9	0	50	80	130
224	Cove	Mesa IV, West Mine	0	1	7	8	0	50	70	120
225	Cove	Mesa I Mine 11	0	0	10	10	0	0	100	100
226	Cove	Mesa I Mine 15	0	0	11	11	0	0	110	110
227	Cove	Mesa I Mine 10	0	1	9	10	0	50	90	140
228	Cove	Mesa I Mine 13	0	1	9	10	0	50	90	140
229	Cove	Mesa I Mine 12	0	0	10	10	0	0	100	100
230	Cove	Mesa I Mine 14	0	0	7	7	0	0	70	70
231	Round Rock	Jimmie King No. 9 Mine	0	0	3	3	0	0	30	30
232	Cove	Mesa IV, East Side	0	0	7	7	0	0	70	70
233	Cove	Mesa III, Northwest Mine	0	0	7	7	0	0	70	70
234	Cove	Cov000	0	0	7	7	0	0	70	70
235	Cove	Mesa III, West Mine	0	0	8	8	0	0	80	80
236	Cove	Mesa III Mine	0	0	7	7	0	0	70	70
237	Cove	Mesa II 1/2, Mine 4	0	0	7	7	0	0	70	70
238	Cove	Mesa II 1/2 Mine	0	0	7	7	0	0	70	70
239	Cove	NA-0313	0	0	7	7	0	0	70	70
240	Cove	Mesa II 1/4 Mine	0	0	7	7	0	0	70	70
241	Cove	Mesa II, Mine 4	0	0	7	7	0	0	70	70
242	Cove	Henry Phillips Mine	0	0	7	7	0	0	70	70
243	Cove	Mesa I 1/2 Mine	0	0	6	6	0	0	60	60
244	Cove	Mesa II, Mine No. 1, P-150	0	0	7	7	0	0	70	70
245	Cove	Mesa II, Mine No. 1 & 2, P-21	0	0	7	7	0	0	70	70
246	Cove	Mesa I 3/4, Mine No. 2, P150	0	0	7	7	0	0	70	70
247	Cove	Mesa I 1/2, West Mine	0	0	6	6	0	0	60	60
248	Cove	Mesa I 1/4 Mine	0	1	5	6	0	50	50	100
249	Round Rock	NA-0333	0	0	4	4	0	0	40	40
250	Round Rock	NA-0332	0	0	4	4	0	0	40	40
251	Round Rock	Tommy James Mine	0	0	5	5	0	0	50	50
252	Round Rock	Step Mesa Mine	0	0	6	6	0	0	60	60
253	Cove	Mesa I 3/4 Incline	0	0	8	8	0	0	80	80
254	Round Rock	Flag No. 1 Mine	0	0	7	7	0	0	70	70
255	Round Rock	Black No. 1 Mine	0	0	6	6	0	0	60	60
256	Round Rock	Black No. 2 Mine (West)	0	0	5	5	0	0	50	50
257	Round Rock	Black No. 2 Mine	0	0	5	5	0	0	50	50
258	Cove	Billy Topaha Mine	0	0	5	5	0	0	50	50
259	Round Rock	Joleo Mine	0	0	5	5	0	0	50	50
260	Round Rock	Cisco Mine	0	0	5	5	0	0	50	50
261	Round Rock	Camp Mine	0	0	4	4	0	0	40	40
262	Round Rock	Knife Edge Mesa Mine	0	0	6	6	0	0	60	60
263	Round Rock	NA-0343	0	0	6	6	0	0	60	60
264	Red Valley	Rocky Spring Mine	1	0	5	6	100	0	50	150
265	Red Valley	H. B. Roy No. 1	0	0	3	3	0	0	30	30
266	Sanostee	Key and Tohe	0	0	2	2	0	0	20	20
267	Sanostee	Castle Tsosie	0	0	1	1	0	0	10	10
268	Sanostee	Joe Ben 1	0	0	1	1	0	0	10	10
269	Sanostee	Joe Ben 2	0	0	1	1	0	0	10	10
270	Sanostee	Deneh Nezz 3	0	0	1	1	0	0	10	10
271	Sanostee	Deneh Nezz 1, 2	0	0	1	1	0	0	10	10
272	Sanostee	Enos Johnson Claim?	0	0	1	1	0	0	10	10
273	Sanostee	John Joe 1	0	0	1	1	0	0	10	10
274	Sanostee	Enos Johnson	0	0	1	1	0	0	10	10
275	Sanostee	Enos Johnson	0	0	1	1	0	0	10	10
276	Sanostee	Joe Ben 3	0	0	1	1	0	0	10	10
277	Sanostee	NA-0603	0	0	1	1	0	0	10	10
278	Sanostee	Enos Johnson 3	0	0	1	1	0	0	10	10
279	Sanostee	Enos Johnson 1, Enos Johnson 2	0	0	1	1	0	0	10	10
280	Sanostee	Enos Johnson	0	0	1	1	0	0	10	10
281	Sanostee	Enos Johnson	0	0	1	1	0	0	10	10
282	Sanostee	Horace Ben	0	0	1	1	0	0	10	10
283	Sanostee	Carl Yazzie 1	0	0	1	1	0	0	10	10
284	Sanostee	H. B. Roy No. 2	0	0	1	1	0	0	10	10
285	Sanostee	Reed Henderson	0	0	0	0	0	0	0	0

SOIL PATHWAY AND AIR PATHWAY

The soil exposure pathway involves direct exposure to hazardous substances and areas of suspected contamination. This pathway differs from the three migration pathways in that it accounts for contact with in-place hazardous substances at the site rather than migration of substances from the site. Evaluation of the soil pathway using the modified HRS required the location of the AUM sites and distance to structures. The HRS criteria used to evaluate the soil pathway were:

- For structures within 200 feet of an AUM site, assign 100 points per structure,
- For structures between 200 feet and 1,320 feet, assign 25 points per structure,
- For structures between 1,320 feet and 1 mile, assign 10 points per structure, and
- If no structures exist within 1 mile, assign 0 points.

The air pathway involves wind that can entrain particulates from mine spoil piles, roads, and other disturbed areas. Waste rock at AUM sites contain radionuclides and metals that may be released as fugitive dust. This material can contaminate areas downwind as particles settle out of suspension in the air (EPA, 2000a). Evaluation of the air pathway using the modified HRS also required the location of AUM sites and distance to structures.

The buffer distances around the AUM sites and the factors associated with each distance are the same for both the soil and air pathways under the modified HRS used for this assessment. Therefore, a single table was generated for both pathways. Table 3 "Soil Pathway and Air Pathway Score" shows the number of structures that occur within 200 feet, 1,320 feet (1/4 mile), and 1 mile of AUM sites. The number of structures within each buffer are multiplied by the scoring factor for each buffer. The scores for each buffer are summed to obtain the total score for each AUM site. The table was sorted by the MAP-ID number. The highest soil pathway score is 2,770 and air pathway score is 2,770 for a total soil and air pathway score of 5,540. The AUM is located at NAMLRP reclamation project site NA-0420 in the Beclabito Chapter (MAP-ID #66). The soil and air pathway scores calculated for this site are based on 0 structures within 200 feet of the AUM, 68 structures in the 200 foot to 1/4 mile buffer, and 107 structures in the 1/4 mile to 1 mile buffer, for a total of 175 structures within 1 mile of the AUM.

Abandoned Uranium Mine

Structures

Wells

Surface Water

Figure 4. Example Photographs of Modified HRS Scoring Factors

Table 3. Soil Pathway and Air Pathway Score.

MAP-ID	Chapter	Mine Name / Identifier	200 Foot Structures Count	1/4 Mile Structures Count	1 Mile Structures Count	Total Structures Count	200 Foot Score	1/4 Mile Score	1 Mile Score	Total Soil Score	Total Air Score
1	Aneth	Pete 6 & 7	0	0	1	1	0	0	10	10	10
2	Red Mesa	NA-0238	0	0	0	0	0	0	0	0	0
3	Aneth	Montezuma Creek Mine	0	0	6	6	0	0	60	60	60
4	Teec Nos Pos	Aneth 1	0	0	7	7	0	0	70	70	70
5	Red Mesa	Tom Morgan 1	0	0	7	7	0	0	70	70	70
6	Red Mesa	Barton 3	0	4	3	7	0	100	30	130	130
7	Red Mesa	John Lee Benally	0	0	7	7	0	0	70	70	70
8	Red Mesa	Phillip Dee 1	0	0	14	14	0	0	140	140	140
9	Red Mesa	NA-0509A	0	6	8	14	0	150	80	230	230
10	Sweetwater	Johnny McCoy 1	0	0	38	38	0	0	380	380	380
11	Teec Nos Pos	John Kee 4	0	5	18	23	0	125	180	305	305
12	Teec Nos Pos	Capitan Benally No. 4A	0	0	8	8	0	0	80	80	80
13	Red Mesa	Brodie 1	0	0	26	26	0	0	260	260	260
14	Teec Nos Pos	Block K	0	3	14	17	0	75	140	215	215
15	Teec Nos Pos	NA-0928	0	4	0	4	0	100	0	100	100
16	Teec Nos Pos	Silentman 1	0	1	10	11	0	25	100	125	125
17	Teec Nos Pos	McKenzie 3	0	1	12	13	0	25	120	145	145
18	Teec Nos Pos	Plot 2	0	1	16	17	0	25	160	185	185
19	Teec Nos Pos	NA-0904	0	0	16	16	0	0	160	160	160
20	Teec Nos Pos	Plot 1	0	0	15	15	0	0	150	150	150
22	Teec Nos Pos	Plot 4	0	0	17	17	0	0	170	170	170
22	Teec Nos Pos	Plot 3	0	1	16	17	0	25	160	185	185
23	Teec Nos Pos	Plot 5	0	1	27	28	0	25	270	295	295
24	Sweetwater	NA-0926	0	0	13	13	0	0	130	130	130
25	Sweetwater	NA-0924	0	0	16	16	0	0	160	160	160
26	Teec Nos Pos	Hoskie Henry	0	8	36	44	0	200	360	560	560
27	Teec Nos Pos	Pope 1	0	0	42	42	0	0	420	420	420
28	Teec Nos Pos	Plot 6	0	9	35	44	0	225	350	575	575
29	Teec Nos Pos	Hoskie Henry	0	9	30	39	0	225	300	525	525
30	Teec Nos Pos	NA-0919B	0	0	27	27	0	0	270	270	270
31	Teec Nos Pos	NA-0919A	0	0	30	30	0	0	300	300	300
32	Teec Nos Pos	Plot 7	0	0	39	39	0	0	390	390	390
33	Teec Nos Pos	Tse079	0	0	41	41	0	0	410	410	410
34	Teec Nos Pos	Plot 8	0	0	40	40	0	0	400	400	400
35	Teec Nos Pos	Black Rock Point Mines	0	4	33	37	0	100	330	430	430
36	Teec Nos Pos	NA-0917A	0	4	36	40	0	100	360	460	460
37	Teec Nos Pos	Plot 9	0	0	20	20	0	0	200	200	200
38	Teec Nos Pos	Jimmie Bileen 1	0	0	17	17	0	0	170	170	170
39	Teec Nos Pos	Sandy K	0	2	15	17	0	50	150	200	200
40	Teec Nos Pos	Plot 10	0	0	20	20	0	0	200	200	200
41	Teec Nos Pos	Plot 11	0	0	17	17	0	0	170	170	170
42	Sweetwater	North Martin	0	1	23	24	0	25	230	255	255
43	Sweetwater	Grover Cleveland 1	0	2	6	8	0	50	60	110	110
44	Sweetwater	Martin Mine	0	0	25	25	0	0	250	250	250
45	Sweetwater	Rattlesnake No. 8	0	0	15	15	0	0	150	150	150
46	Sweetwater	Tsosie 1	0	2	6	8	0	50	60	110	110
47	Sweetwater	George Simpson 1 Incline	0	0	28	28	0	0	280	280	280
48	Sweetwater	Saytah	0	0	30	30	0	0	300	300	300
49	Sweetwater	Carson	0	0	17	17	0	0	170	170	170
50	Sweetwater	AEC Plot 3	0	0	9	9	0	0	90	90	90
51	Sweetwater	Plot 13	0	0	27	27	0	0	270	270	270
52	Sweetwater	Last Chance	0	0	27	27	0	0	270	270	270
53	Sweetwater	Melvin Benally 1	0	0	13	13	0	0	130	130	130
54	Sweetwater	Saytah Canyon	0	0	13	13	0	0	130	130	130
55	Sweetwater	CBW-MC Mine	0	0	14	14	0	0	140	140	140
56	Sweetwater	Saytah Canyon	0	0	12	12	0	0	120	120	120
57	Sweetwater	Benally No. 3	0	3	11	14	0	75	110	185	185
58	Sweetwater	School Boy	0	0	0	0	0	0	0	0	0
59	Teec Nos Pos	Rattlesnake No. 1	0	0	1	1	0	0	10	10	10
60	Teec Nos Pos	Bettie No. 1	0	0	0	0	0	0	0	0	0
61	Beclabito	Zona No. 1	0	0	0	0	0	0	0	0	0
62	Beclabito	Ruben No. 1	0	0	0	0	0	0	0	0	0
63	Beclabito	Jim Lee No. 1, Richard King No. 1	0	0	0	0	0	0	0	0	0
64	Beclabito	Todakonzie No. 1	0	0	0	0	0	0	0	0	0
65	Beclabito	NA-0424	1	9	162	172	100	225	1620	1945	1945
66	Beclabito	NA-0420	0	68	107	175	0	1700	1070	2770	2770
67	Beclabito	Harvey Begay 3	0	0	0	0	0	0	0	0	0
68	Red Valley	Toni Tuc No. 1 Mine	0	0	0	0	0	0	0	0	0
69	Beclabito	Upper Red Canyon Mine	0	0	0	0	0	0	0	0	0
70	Beclabito	King 6	0	2	5	7	0	50	50	100	100
71	Beclabito	Barton & Begay	0	2	5	7	0	50	50	100	100
72	Beclabito	Barton & Begay	0	0	2	2	0	0	20	20	20
73	Beclabito	Rocky Flats 1	0	0	2	2	0	0	20	20	20
74	Beclabito	Bec064	0	0	0	0	0	0	0	0	0
75	Beclabito	Canyon 1	0	0	0	0	0	0	0	0	0
76	Beclabito	Bec068	0	0	0	0	0	0	0	0	0
77	Beclabito	John John 1	0	0	2	2	0	0	20	20	20
78	Beclabito	John John 1	0	0	2	2	0	0	20	20	20
79	Beclabito	Bec054	0	0	2	2	0	0	20	20	20
80	Beclabito	King 2	0	0	2	2	0	0	20	20	20
81	Beclabito	Rocky Flats 2	0	0	0	0	0	0	0	0	0
82	Beclabito	Barton and Lee	0	0	0	0	0	0	0	0	0
83	Beclabito	Barton and Lee	0	0	0	0	0	0	0	0	0
84	Beclabito	Barton and Lee	0	0	3	3	0	0	30	30	30
85	Beclabito	Barton and Lee	0	0	3	3	0	0	30	30	30
86	Sweetwater	Chester Mud 1	0	0	9	9	0	0	90	90	90
87	Sweetwater	Eurida Mine	0	0	5	5	0	0	50	50	50
88	Sweetwater	Plot 14	0	0	2	2	0	0	20	20	20
89	Sweetwater	East Workings	0	0	5	5	0	0	50	50	50
90	Sweetwater	NA-0505B	0	0	5	5	0	0	50	50	50
91	Sweetwater	Plot 16	0	0	5	5	0	0	50	50	50
92	Sweetwater	Plot 15	0	0	0	0	0	0	0	0	0
93	Sweetwater	NA-0504	0	0	8	8	0	0	80	80	80
94	Sweetwater	Chimney No. 1	0	0	0	0	0	0	0	0	0
95	Sweetwater	Sunnyside	0	0	1	1	0	0	10	10	10
96	Sweetwater	Sunnyside	0	0	1	1	0	0	10	10	10
97	Sweetwater	Swt018	0	4	2	6	0	100	20	120	120

Table 3. Soil Pathway and Air Pathway Score (continued)

MAP-ID	Chapter	Mine Name / Identifier	200 Foot Structures Count	1/4 Mile Structures Count	1 Mile Structures Count	Total Structures Count	200 Foot Score	1/4 Mile Score	1 Mile Score	Total Soil Score	Total Air Score
98	Red Valley	Tohe Thlany Begay Mine	0	0	0	0	0	0	0	0	0
99	Red Valley	Cov192	0	0	0	0	0	0	0	0	0
100	Sweetwater	AEC Plot B	0	0	4	4	0	0	40	40	40
101	Sweetwater	Mildred 1	0	0	0	0	0	0	0	0	0
102	Sweetwater	NA-0512	0	0	1	1	0	0	10	10	10
103	Sweetwater	AEC Plot D	0	0	2	2	0	0	20	20	20
104	Sweetwater	Sheepskin Mesa	0	0	1	1	0	0	10	10	10
105	Sweetwater	Tree Mesa	0	0	1	1	0	0	10	10	10
106	Sweetwater	Swt003	0	0	1	1	0	0	10	10	10
107	Sweetwater	NA-0510	0	0	0	0	0	0	0	0	0
108	Sweetwater	Kinusta Mesa	0	0	2	2	0	0	20	20	20
109	Sweetwater	NA-0511	0	0	2	2	0	0	20	20	20
110	Sweetwater	Cove Mesa Mines (Cato Sells)	0	0	0	0	0	0	0	0	0
111	Red Valley	Cove Mesa Mines (Cato Sells)	0	0	1	1	0	0	10	10	10
112	Red Valley	Cove Mesa Mines (Cato Sells)	0	0	1	1	0	0	10	10	10
113	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
114	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
115	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
116	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
117	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
118	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
119	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
120	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
121	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
122	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
123	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
124	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
125	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
126	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
127	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
128	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	0	0	0	0	0	0
129	Red Valley	Cottonwood Butte Mine	0	0	3	3	0	0	30	30	30
130	Red Valley	Syracuse Mine	0	0	0	0	0	0	0	0	0
131	Red Valley	Hazel Mine	0	0	3	3	0	0	30	30	30
132	Red Valley	NA-0410	0	0	3	3	0	0	30	30	30
133	Red Valley	North Star Mine	0	0	3	3	0	0	30	30	30
134	Red Valley	Lone Star Mine	0	0	3	3	0	0	30	30	30
135	Red Valley	Valley View Mine	0	0	5	5	0	0	50	50	50
136	Red Valley	White Cap Mine	0	0	0	0	0	0	0	0	0
137	Red Valley	Upper Canyon Mine	0	0	16	16	0	0	160	160	160
138	Red Valley	Leroy Mine	0	0	13	13	0	0	130	130	130
139	Red Valley	Lower Canyon Mine	0	0	13	13	0	0	130	130	130
140	Red Valley	NA-0405	0	0	20	20	0	0	200	200	200
141	Red Valley	Oak Springs Mine (Gravel Cap)	1	10	19	30	100	250	190	540	540
142	Red Valley	Oak Springs Mine	0	11	20	31	0	275	200	475	475
143	Red Valley	Oak238	0	1	21	22	0	25	210	235	235
144	Red Valley	VCA Plot 7 Mines	0	1	17	18	0	25	170	195	195
145	Red Valley	VCA Plot 7 Mines	0	1	11	12	0	25	110	135	135
146	Red Valley	Franks Point Mine	0	0	7	7	0	0	70	70	70
147	Red Valley	Upper Salt Rock Canyon Mine	0	0	9	9	0	0	90	90	90
148	Red Valley	VCA Plot 7 Mines	0	0	3	3	0	0	30	30	30
149	Red Valley	Lower Salt Rock Canyon Mine	0	0	3	3	0	0	30	30	30
150	Red Valley	Williams Point Mine	0	0	4	4	0	0	40	40	40
151	Red Valley	Salt Canyon Mines	0	0	0	0	0	0	0	0	0
152	Red Valley	Salt Canyon Mines	0	0	1	1	0	0	10	10	10
153	Red Valley	NA-0814	0	0	15	15	0	0	150	150	150
154	Red Valley	Lookout Point Mines	0	0	9	9	0	0	90	90	90
155	Red Valley	Lookout Point Incline Mine	0	0	19	19	0	0	190	190	190
156	Red Valley	Stripped Area 1 of VCA Plot 3	0	0	13	13	0	0	130	130	130
157	Red Valley	VCA Plot 3	0	0	2	2	0	0	20	20	20
158	Red Valley	Shadyside No. 2 Mine	0	0	3	3	0	0	30	30	30
159	Red Valley	Shadyside No. 1 Mine	0	0	5	5	0	0	50	50	50
160	Red Valley	VCA Plot 3	0	0	4	4	0	0	40	40	40
161	Red Valley	Begay No. 2 Mine	0	0	4	4	0	0	40	40	40
162	Red Valley	Begay Incline	0	0	9	9	0	0	90	90	90
163	Red Valley	Stripped Area 2 of VCA Plot 3	0	0	12	12	0	0	120	120	120
164	Red Valley	Shadyside Incline	0	0	9	9	0	0	90	90	90
165	Red Valley	NA-0809	0	0	21	21	0	0	210	210	210
166	Red Valley	NA-0822	0	0	46	46	0	0	460	460	460
167	Red Valley	Nelson Point Mine	0	0	36	36	0	0	360	360	360
168	Red Valley	Tent Mine	0	0	20	20	0	0	200	200	200
169	Red Valley	Oak143, Oak146	0	0	35	35	0	0	350	350	350
170	Red Valley	NA-0806	0	0	45	45	0	0	450	450	450
171	Red Valley	NA-0821	0	0	44	44	0	0	440	440	440
172	Red Valley	Oak156	0	0	46	46	0	0	460	460	460
173	Red Valley	Stripped Area 3 of VCA Plot 3	0	0	46	46	0	0	460	460	460
174	Red Valley	NA-0824	0	0	6	6	0	0	60	60	60
175	Red Valley	Junction Mine	0	0	8	8	0	0	80	80	80
176	Red Valley	King Tutt Point Mines	0	2	16	18	0	50	160	210	210
177	Red Valley	Carrizo No. 1 Mine	0	0	9	9	0	0	90	90	90
178	Red Valley	Begay No. 1 Mine	0	2	7	9	0	50	70	120	120
179	Red Valley	King Tutt No. 1 Mine	0	2	7	9	0	50	70	120	120
180	Red Valley	Red Wash Point Mine	0	3	6	9	0	75	60	135	135
181	Red Valley	Oak124, Oak125	0	2	7	9	0	50	70	120	120
182	Red Valley	Begay No. 1 Mine	0	2	7	9	0	50	70	120	120
183	Red Valley	Alongo Mines	0	5	2	7	0	125	20	145	145
184	Red Valley	Red Rock Mine	0	1	37	38	0	25	370	395	395
185	Red Valley	NA-0828	0	1	28	29	0	25	280	305	305
186	Red Valley	Oak230	0	0	29	29	0	0	290	290	290
187	Red Valley	Red Wash Mine (Leroy Pettigrew)	0	0	29	29	0	0	290	290	290
188	Red Valley	Red Wash Mine (Hosteen S. Begay)	0	0	8	8	0	0	80	80	80
189	Red Valley	Upper Red Wash Mine	1	0	2	3	100	0	20	120	120
190	Red Valley	Upper Red Wash Mine	0	1	1	2	0	25	10	35	35
191	Shiprock	Climax Transfer Station	0	9	148	157	0	225	1480	1705	1705
192	Red Valley	East Mesa Mines	0	0	0	0	0	0	0	0	0
194	Cove	West Mesa Mine	0	0	0	0	0	0	0	0	0
194	Red Valley	Cove Transfer Station	2	22	127	151	200	550	1270	2020	2020

Table 3. Soil Pathway and Air Pathway Score (continued)

MAP-ID	Chapter	Mine Name / Identifier	200 Foot Structures Count	1/4 Mile Structures Count	1 Mile Structures Count	Total Structures Count	200 Foot Score	1/4 Mile Score	1 Mile Score	Total Soil Score	Total Air Score
195	Round Rock	Mexican Cry Mine	0	0	0	0	0	0	0	0	0
196	Round Rock	Mexican Cry Mine	0	0	0	0	0	0	0	0	0
197	Round Rock	Hall Mine	0	0	0	0	0	0	0	0	0
198	Round Rock	Cov198	0	0	0	0	0	0	0	0	0
199	Round Rock	Nakai Chee Begay Mine	0	0	0	0	0	0	0	0	0
200	Cove	Cato No. 2	0	0	1	1	0	0	10	10	10
201	Cove	Cato No. 1 Pit	0	0	33	33	0	0	330	330	330
202	Cove	Frank Jr. Mine	0	0	6	6	0	0	60	60	60
203	Cove	NA-0319	0	0	2	2	0	0	20	20	20
204	Cove	Mesa VI Mine	0	0	2	2	0	0	20	20	20
205	Cove	NA-0319	0	0	2	2	0	0	20	20	20
206	Cove	Mesa V Adit	0	0	0	0	0	0	0	0	0
207	Cove	Mesa V Incline	0	0	0	0	0	0	0	0	0
208	Cove	Mesa V Mine	0	0	0	0	0	0	0	0	0
209	Cove	Mesa V Mine	0	0	2	2	0	0	20	20	20
210	Cove	NA-0318	0	0	0	0	0	0	0	0	0
211	Cove	Cov087	0	0	2	2	0	0	20	20	20
212	Cove	Mesa IV 1/2 Mine	0	0	2	2	0	0	20	20	20
213	Cove	North Portal, Frank No. 1 Mine	0	0	2	2	0	0	20	20	20
214	Cove	East Portal, Frank No. 1 Mine	0	0	2	2	0	0	20	20	20
215	Cove	Frank No. 2	0	0	2	2	0	0	20	20	20
216	Cove	South Portal, Frank No. 1 Mine	0	0	2	2	0	0	20	20	20
217	Cove	NA-0316	0	0	2	2	0	0	20	20	20
218	Cove	Cov068	0	0	0	0	0	0	0	0	0
219	Cove	Mesa IV, Mine No. 2	0	0	0	0	0	0	0	0	0
220	Cove	Mesa IV, Mine No. 3	0	0	0	0	0	0	0	0	0
221	Cove	Mesa IV, Mine No. 1	0	0	1	1	0	0	10	10	10
222	Cove	Mesa II Pit	0	0	0	0	0	0	0	0	0
223	Cove	Mesa IV 1/4 Mine	0	0	2	2	0	0	20	20	20
224	Cove	Mesa IV, West Mine	0	0	3	3	0	0	30	30	30
225	Cove	Mesa I Mine 11	0	0	0	0	0	0	0	0	0
226	Cove	Mesa I Mine 15	0	0	0	0	0	0	0	0	0
227	Cove	Mesa I Mine 10	0	0	0	0	0	0	0	0	0
228	Cove	Mesa I Mine 13	0	0	0	0	0	0	0	0	0
229	Cove	Mesa I Mine 12	0	0	0	0	0	0	0	0	0
230	Cove	Mesa I Mine 14	0	0	0	0	0	0	0	0	0
231	Round Rock	Jimmie King No. 9 Mine	0	0	0	0	0	0	0	0	0
232	Cove	Mesa IV, East Side	0	0	1	1	0	0	10	10	10
233	Cove	Mesa III, Northwest Mine	0	1	0	1	0	25	0	25	25
234	Cove	Cov000	0	0	1	1	0	0	10	10	10
235	Cove	Mesa III, West Mine	0	1	0	1	0	25	0	25	25
236	Cove	Mesa III Mine	0	1	0	1	0	25	0	25	25
237	Cove	Mesa II 1/2, Mine 4	0	1	0	1	0	25	0	25	25
238	Cove	Mesa II 1/2 Mine	0	0	1	1	0	0	10	10	10
239	Cove	NA-0313	0	0	1	1	0	0	10	10	10
240	Cove	Mesa II 1/4 Mine	0	0	1	1	0	0	10	10	10
241	Cove	Mesa II, Mine 4	0	0	0	0	0	0	0	0	0
242	Cove	Henry Phillips Mine	0	0	0	0	0	0	0	0	0
243	Cove	Mesa I 1/2 Mine	0	0	0	0	0	0	0	0	0
244	Cove	Mesa II, Mine No. 1, P-150	0	0	1	1	0	0	10	10	10
245	Cove	Mesa II, Mine No. 1 & 2, P-21	0	0	1	1	0	0	10	10	10
246	Cove	Mesa I 3/4, Mine No. 2, P150	0	0	1	1	0	0	10	10	10
247	Cove	Mesa I 1/2, West Mine	0	0	0	0	0	0	0	0	0
248	Cove	Mesa I 1/4 Mine	0	0	3	3	0	0	30	30	30
249	Round Rock	NA-0333	0	0	0	0	0	0	0	0	0
250	Round Rock	NA-0332	0	0	0	0	0	0	0	0	0
251	Round Rock	Tommy James Mine	0	0	0	0	0	0	0	0	0
252	Round Rock	Step Mesa Mine	0	0	0	0	0	0	0	0	0
253	Cove	Mesa I 3/4 Incline	0	0	0	0	0	0	0	0	0
254	Round Rock	Flag No. 1 Mine	0	0	0	0	0	0	0	0	0
255	Round Rock	Black No. 1 Mine	0	0	0	0	0	0	0	0	0
256	Round Rock	Black No. 2 Mine (West)	0	0	0	0	0	0	0	0	0
257	Round Rock	Black No. 2 Mine	0	0	0	0	0	0	0	0	0
258	Cove	Billy Topaha Mine	0	0	0	0	0	0	0	0	0
259	Round Rock	Joleo Mine	0	0	0	0	0	0	0	0	0
260	Round Rock	Cisco Mine	0	0	0	0	0	0	0	0	0
261	Round Rock	Camp Mine	0	0	0	0	0	0	0	0	0
262	Round Rock	Knife Edge Mesa Mine	0	0	0	0	0	0	0	0	0
263	Round Rock	NA-0343	0	0	0	0	0	0	0	0	0
264	Red Valley	Rocky Spring Mine	0	2	28	30	0	50	280	330	330
265	Red Valley	H. B. Roy No. 1	0	0	0	0	0	0	0	0	0
266	Sanostee	Key and Tohe	0	0	2	2	0	0	20	20	20
267	Sanostee	Castle Tsosie	0	0	0	0	0	0	0	0	0
268	Sanostee	Joe Ben 1	0	0	0	0	0	0	0	0	0
269	Sanostee	Joe Ben 2	0	0	0	0	0	0	0	0	0
270	Sanostee	Deneh Nezz 3	0	0	0	0	0	0	0	0	0
271	Sanostee	Deneh Nezz 1, 2	0	0	0	0	0	0	0	0	0
272	Sanostee	Enos Johnson Claim?	0	0	0	0	0	0	0	0	0
273	Sanostee	John Joe 1	0	0	0	0	0	0	0	0	0
274	Sanostee	Enos Johnson	0	0	0	0	0	0	0	0	0
275	Sanostee	Enos Johnson	0	0	0	0	0	0	0	0	0
276	Sanostee	Joe Ben 3	0	0	0	0	0	0	0	0	0
277	Sanostee	NA-0603	0	0	0	0	0	0	0	0	0
278	Sanostee	Enos Johnson 3	0	0	0	0	0	0	0	0	0
279	Sanostee	Enos Johnson 1, Enos Johnson 2	0	0	0	0	0	0	0	0	0
280	Sanostee	Enos Johnson	0	0	0	0	0	0	0	0	0
281	Sanostee	Enos Johnson	0	0	0	0	0	0	0	0	0
282	Sanostee	Horace Ben	0	0	0	0	0	0	0	0	0
283	Sanostee	Carl Yazzie 1	0	0	0	0	0	0	0	0	0
284	Sanostee	H. B. Roy No. 2	0	0	1	1	0	0	10	10	10
285	Sanostee	Reed Henderson	0	0	0	0	0	0	0	0	0

COMBINED PATHWAYS

Once total scores were developed for each of the four pathways it was possible to tabulate a combined pathways score for each of the AUM sites. Scores for air, soil, surface water, and groundwater were summed to obtain combined scores, which are presented in Table 4 "Combined Pathway Score." The table was sorted by MAP-ID number.

The GIS database was used to generate several maps depicting the combined pathways results. Figure 6 "Combined Pathways – Map Index" shows the surface extents of the AUM sites and the aggregated buffers that were generated around the surface extents of the AUM sites. Also shown on Figure 6 are the extents of the eleven map enlargements for the combined pathways:

Figure 7 Combined Pathways in the North Central Aneth Region
Figure 8 Combined Pathways in the Northwest Red Mesa Region
Figure 9 Combined Pathways in the North Teec Nos Pos Region
Figure 10 Combined Pathways in the South Red Mesa Region
Figure 11 Combined Pathways in the Tse Tah Region
Figure 12 Combined Pathways in the Northeast Carrizo Region
Figure 13 Combined Pathways in the Southwest Sweetwater Region
Figure 14 Combined Pathways in the West Carrizo Region
Figure 15 Combined Pathways in the East Carrizo Region
Figure 16 Combined Pathways in the Shiprock Region
Figure 17 Combined Pathways in the Lukachukai Region
Figure 18 Combined Pathways in the Chuska Region

The map enlargements show the AUM sites labeled with their corresponding MAP-ID, as well as the structures, wells, and drainages. Table 5 below lists the map figure number and the range of MAP-IDs on each map. Also shown on the maps are sites that have been entered into the EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). Additional information regarding the CERCLIS sites can be obtained from EPA Region 9.

FIGURE NUMBER	RANGE OF MAP-IDS
Figure 7	1
Figure 8	2
Figure 9	3 - 4
Figure 10	5 - 10
Figure 11	11 - 58
Figure 12	59 - 85

FIGURE NUMBER	RANGE OF MAP-IDS
Figure 13	86
Figure 14	87 - 128
Figure 15	129 - 190
Figure 16	191
Figure 17	192 - 263
Figure 18	264 - 285

Table 5. MAP-ID Correspondence to Figure Number.

Based on the modified HRS model used for this assessment, scores for AUM sites within the Northern AUM Region range from 160 to 5,910. The AUM site identified by MAP-ID #66 (NA-0420) has the highest combined pathway score (5,910) within the Northern AUM Region. Figure 5 shows a photograph taken from the NA-0420 site, and the location of NA-0420 (MAP-ID #66) is shown on Figure 12. In Figure 12 it is possible to see the Air and Soil Pathway contributions of 0 structures within the 200 foot buffer around and including the AUM, 68 structures between 200 feet and 1/4 mile, and 107 structures between 1/4 mile and 1 mile. The Groundwater Pathway contributions are shown by 0 wells within 1/4 mile, 3 wells between 1/4 mile and 1 mile, and 6 wells between 1 mile and 4 miles of the AUM site. The Surface Water Pathway contribution is shown by the downstream drainage from the AUM site through each of the buffers.

Figure 5. Photograph Taken from NA-0420 AUM Site (MAP-ID #66) Located in the Beclabito Chapter Looking Northwest. This NAMLRP reclaimed site received the highest score due to the close proximity of numerous dwellings and several wells.

Table 4. Combined Pathway Score.

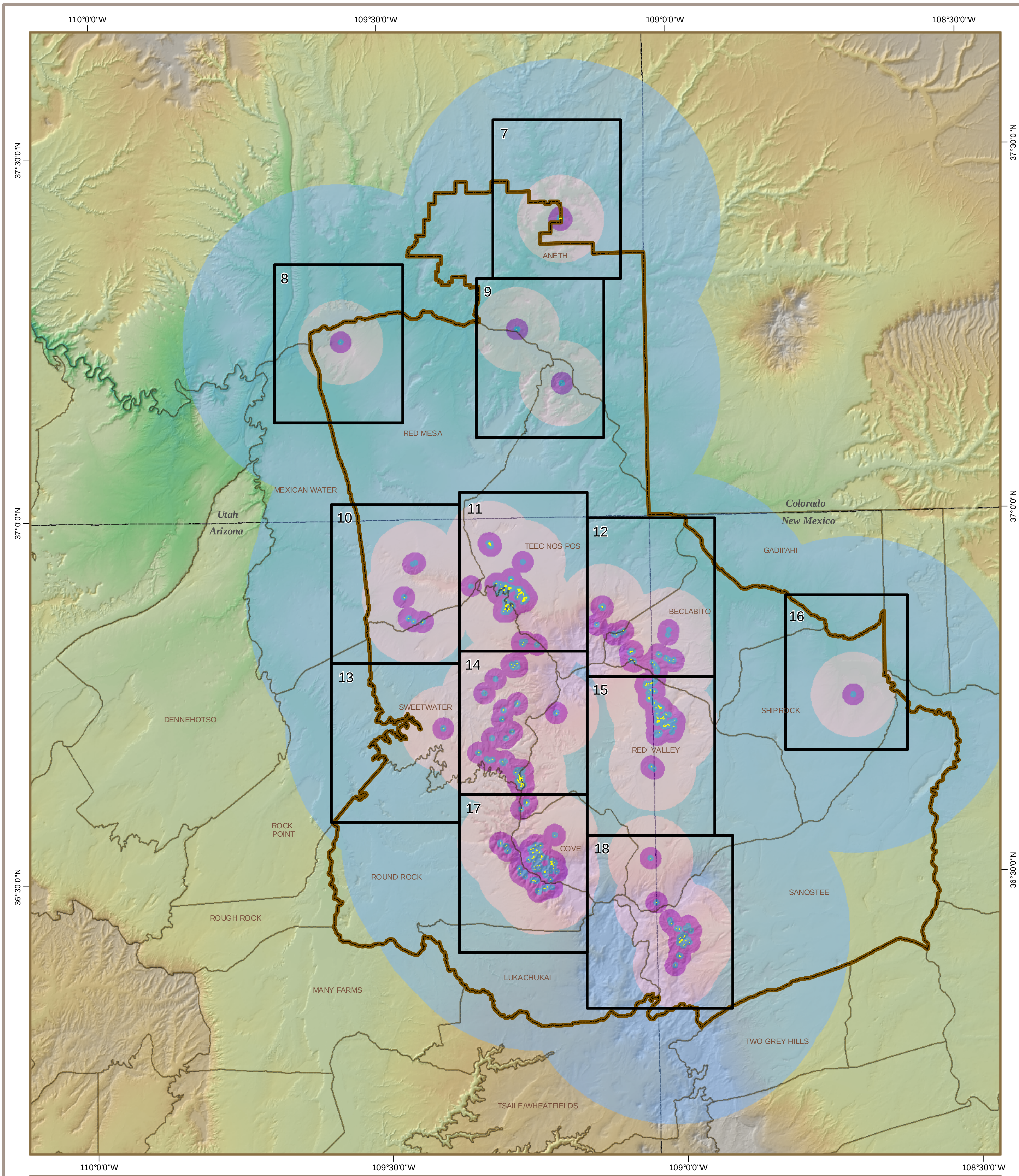
MAP-ID	Chapters	Mine Name / Identifier	Total Soil Score	Total Air Score	Total Groundwater Score	Total Surface Water Score	Combined Score
1	Aneth	Pete 6 & 7	10	10	120	160	300
2	Red Mesa	NA-0238	0	0	360	160	520
3	Aneth	Montezuma Creek Mine	60	60	390	160	670
4	Teec Nos Pos	Aneth 1	70	70	320	160	620
5	Red Mesa	Tom Morgan 1	70	70	40	160	340
6	Red Mesa	Barton 3	130	130	50	160	470
7	Red Mesa	John Lee Benally	70	70	120	160	420
8	Red Mesa	Phillip Dee 1	140	140	180	160	620
9	Red Mesa	NA-0509A	230	230	230	160	850
10	Sweetwater	Johnny McCoy 1	380	380	470	160	1390
11	Teec Nos Pos	John Kee 4	305	305	240	160	1010
12	Teec Nos Pos	Capitan Benally No. 4A	80	80	110	160	430
13	Red Mesa	Brodie 1	260	260	150	160	830
14	Teec Nos Pos	Block K	215	215	240	160	830
15	Teec Nos Pos	NA-0928	100	100	270	160	630
16	Teec Nos Pos	Silentman 1	125	125	230	160	640
17	Teec Nos Pos	McKenzie 3	145	145	350	160	800
18	Teec Nos Pos	Plot 2	185	185	350	160	880
19	Teec Nos Pos	NA-0904	160	160	370	160	850
20	Teec Nos Pos	Plot 1	150	150	390	160	850
22	Teec Nos Pos	Plot 4	170	170	300	160	800
22	Teec Nos Pos	Plot 3	185	185	260	160	790
23	Teec Nos Pos	Plot 5	295	295	290	160	1040
24	Sweetwater	NA-0926	130	130	310	160	730
25	Sweetwater	NA-0924	160	160	290	160	770
26	Teec Nos Pos	Hoskie Henry	560	560	190	160	1470
27	Teec Nos Pos	Pope 1	420	420	230	160	1230
28	Teec Nos Pos	Plot 6	575	575	240	160	1550
29	Teec Nos Pos	Hoskie Henry	525	525	200	160	1410
30	Teec Nos Pos	NA-0919B	270	270	230	160	930
31	Teec Nos Pos	NA-0919A	300	300	230	160	990
32	Teec Nos Pos	Plot 7	390	390	240	160	1180
33	Teec Nos Pos	Tse079	410	410	240	160	1220
34	Teec Nos Pos	Plot 8	400	400	240	160	1200
35	Teec Nos Pos	Black Rock Point Mines	430	430	240	160	1260
36	Teec Nos Pos	NA-0917A	460	460	240	160	1320
37	Teec Nos Pos	Plot 9	200	200	240	160	800
38	Teec Nos Pos	Jimmie Bileen 1	170	170	240	160	740
39	Teec Nos Pos	Sandy K	200	200	240	160	800
40	Teec Nos Pos	Plot 10	200	200	330	160	890
41	Teec Nos Pos	Plot 11	170	170	280	160	780
42	Sweetwater	North Martin	255	255	520	160	1190
43	Sweetwater	Grover Cleveland 1	110	110	560	160	940
44	Sweetwater	Martin Mine	250	250	660	160	1320
45	Sweetwater	Rattlesnake No. 8	150	150	760	160	1220
46	Sweetwater	Tsosie 1	110	110	600	160	980
47	Sweetwater	George Simpson 1 Incline	280	280	710	160	1430
48	Sweetwater	Saytah	300	300	670	160	1430
49	Sweetwater	Carson	170	170	870	160	1370
50	Sweetwater	AEC Plot 3	90	90	760	160	1100
51	Sweetwater	Plot 13	270	270	920	160	1620
52	Sweetwater	Last Chance	270	270	700	160	1400
53	Sweetwater	Melvin Benally 1	130	130	140	160	560
54	Sweetwater	Saytah Canyon	130	130	140	160	560
55	Sweetwater	CBW-MC Mine	140	140	160	160	600
56	Sweetwater	Saytah Canyon	120	120	160	160	560
57	Sweetwater	Benally No. 3	185	185	120	160	650
58	Sweetwater	School Boy	0	0	100	160	260
59	Teec Nos Pos	Rattlesnake No. 1	10	10	180	160	360
60	Teec Nos Pos	Bettie No. 1	0	0	50	160	210
61	Beclabito	Zona No. 1	0	0	80	160	240
62	Beclabito	Ruben No. 1	0	0	80	160	240
63	Beclabito	Jim Lee No. 1, Richard King No. 1	0	0	140	160	300
64	Beclabito	Todakonzie No. 1	0	0	90	160	250
65	Beclabito	NA-0424	1945	1945	310	160	4360
66	Beclabito	NA-0420	2770	2770	210	160	5910
67	Beclabito	Harvey Begay 3	0	0	140	160	300
68	Red Valley	Toni Tuc No. 1 Mine	0	0	100	160	260
69	Beclabito	Upper Red Canyon Mine	0	0	100	160	260
70	Beclabito	King 6	100	100	110	160	470
71	Beclabito	Barton & Begay	100	100	100	160	460
72	Beclabito	Barton & Begay	20	20	180	160	380
73	Beclabito	Rocky Flats 1	20	20	140	160	340
74	Beclabito	Bec064	0	0	110	160	270
75	Beclabito	Canyon 1	0	0	110	160	270
76	Beclabito	Bec068	0	0	110	160	270
77	Beclabito	John John 1	20	20	140	160	340
78	Beclabito	John John 1	20	20	130	160	330
79	Beclabito	Bec054	20	20	130	160	330
80	Beclabito	King 2	20	20	130	160	330
81	Beclabito	Rocky Flats 2	0	0	130	160	290
82	Beclabito	Barton and Lee	0	0	130	160	290
83	Beclabito	Barton and Lee	0	0	180	160	340
84	Beclabito	Barton and Lee	30	30	180	160	400
85	Beclabito	Barton and Lee	30	30	170	160	390
86	Sweetwater	Chester Mud 1	90	90	10	160	350
87	Sweetwater	Eurida Mine	50	50	20	160	280
88	Sweetwater	Plot 14	20	20	20	160	220
89	Sweetwater	East Workings	50	50	10	160	270
90	Sweetwater	NA-0505B	50	50	10	160	270
91	Sweetwater	Plot 16	50	50	10	160	270
92	Sweetwater	Plot 15	0	0	10	160	170
93	Sweetwater	NA-0504	80	80	20	160	340
94	Sweetwater	Chimney No. 1	0	0	10	160	170
95	Sweetwater	Sunnyside	10	10	0	160	180
96	Sweetwater	Sunnyside	10	10	0	160	180
97	Sweetwater	Swt018	120	120	0	160	400

Table 4. Combined Pathway Score (continued).

MAP-ID	Chapters	Mine Name / Identifier	Total Soil Score	Total Air Score	Total Groundwater Score	Total Surface Water Score	Combined Score
98	Red Valley	Tohe Thlany Begay Mine	0	0	0	160	160
99	Red Valley	Cov192	0	0	0	160	160
100	Sweetwater	AEC Plot B	40	40	0	160	240
101	Sweetwater	Mildred 1	0	0	0	160	160
102	Sweetwater	NA-0512	10	10	0	160	180
103	Sweetwater	AEC Plot D	20	20	0	160	200
104	Sweetwater	Sheepskin Mesa	10	10	0	160	180
105	Sweetwater	Tree Mesa	10	10	0	160	180
106	Sweetwater	Swt003	10	10	0	160	180
107	Sweetwater	NA-0510	0	0	0	160	160
108	Sweetwater	Kinusta Mesa	20	20	0	160	200
109	Sweetwater	NA-0511	20	20	0	160	200
110	Sweetwater	Cove Mesa Mines (Cato Sells)	0	0	10	160	170
111	Red Valley	Cove Mesa Mines (Cato Sells)	10	10	10	160	190
112	Red Valley	Cove Mesa Mines (Cato Sells)	10	10	10	160	190
113	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
114	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
115	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
116	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
117	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
118	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
119	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
120	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
121	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	10	160	170
122	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
123	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
124	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
125	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
126	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
127	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
128	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	20	160	180
129	Red Valley	Cottonwood Butte Mine	30	30	190	160	410
130	Red Valley	Syracuse Mine	0	0	170	160	330
131	Red Valley	Hazel Mine	30	30	180	160	400
132	Red Valley	NA-0410	30	30	210	160	430
133	Red Valley	North Star Mine	30	30	220	160	440
134	Red Valley	Lone Star Mine	30	30	210	160	430
135	Red Valley	Valley View Mine	50	50	160	160	420
136	Red Valley	White Cap Mine	0	0	170	160	330
137	Red Valley	Upper Canyon Mine	160	160	260	160	740
138	Red Valley	Leroy Mine	130	130	260	160	680
139	Red Valley	Lower Canyon Mine	130	130	250	160	670
140	Red Valley	NA-0405	200	200	250	160	810
141	Red Valley	Oak Springs Mine (Gravel Cap)	540	540	410	160	1650
142	Red Valley	Oak Springs Mine	475	475	410	160	1520
143	Red Valley	Oak238	235	235	270	160	900
144	Red Valley	VCA Plot 7 Mines	195	195	270	160	820
145	Red Valley	VCA Plot 7 Mines	135	135	270	160	700
146	Red Valley	Franks Point Mine	70	70	200	160	500
147	Red Valley	Upper Salt Rock Canyon Mine	90	90	240	160	580
148	Red Valley	VCA Plot 7 Mines	30	30	190	160	410
149	Red Valley	Lower Salt Rock Canyon Mine	30	30	190	160	410
150	Red Valley	Williams Point Mine	40	40	280	160	520
151	Red Valley	Salt Canyon Mines	0	0	230	160	390
152	Red Valley	Salt Canyon Mines	10	10	230	160	410
153	Red Valley	NA-0814	150	150	320	160	780
154	Red Valley	Lookout Point Mines	90	90	280	160	620
155	Red Valley	Lookout Point Incline Mine	190	190	320	160	860
156	Red Valley	Stripped Area 1 of VCA Plot 3	130	130	320	160	740
157	Red Valley	VCA Plot 3	20	20	180	160	380
158	Red Valley	Shadyside No. 2 Mine	30	30	180	160	400
159	Red Valley	Shadyside No. 1 Mine	50	50	190	160	450
160	Red Valley	VCA Plot 3	40	40	190	160	430
161	Red Valley	Begay No. 2 Mine	40	40	190	160	430
162	Red Valley	Begay Incline	90	90	190	160	530
163	Red Valley	Stripped Area 2 of VCA Plot 3	120	120	320	160	720
164	Red Valley	Shadyside Incline	90	90	270	160	610
165	Red Valley	NA-0809	210	210	360	160	940
166	Red Valley	NA-0822	460	460	410	160	1490
167	Red Valley	Nelson Point Mine	360	360	370	160	1250
168	Red Valley	Tent Mine	200	200	370	160	930
169	Red Valley	Oak143, Oak146	350	350	320	160	1180
170	Red Valley	NA-0806	450	450	400	160	1460
171	Red Valley	NA-0821	440	440	400	160	1440
172	Red Valley	Oak156	460	460	400	160	1480
173	Red Valley	Stripped Area 3 of VCA Plot 3	460	460	400	160	1480
174	Red Valley	NA-0824	60	60	280	160	560
175	Red Valley	Junction Mine	80	80	230	160	550
176	Red Valley	King Tutt Point Mines	210	210	260	160	840
177	Red Valley	Carrizo No. 1 Mine	90	90	180	160	520
178	Red Valley	Begay No. 1 Mine	120	120	180	160	580
179	Red Valley	King Tutt No. 1 Mine	120	120	220	160	620
180	Red Valley	Red Wash Point Mine	135	135	220	160	650
181	Red Valley	Oak124, Oak125	120	120	180	160	580
182	Red Valley	Begay No. 1 Mine	120	120	220	160	620
183	Red Valley	Alongo Mines	145	145	230	160	680
184	Red Valley	Red Rock Mine	395	395	300	160	1250
185	Red Valley	NA-0828	305	305	260	160	1030
186	Red Valley	Oak230	290	290	260	160	1000
187	Red Valley	Red Wash Mine (Leroy Pettigrew)	290	290	260	160	1000
188	Red Valley	Red Wash Mine (Hosteen S. Begay)	80	80	170	160	490
189	Red Valley	Upper Red Wash Mine	120	120	140	160	540
190	Red Valley	Upper Red Wash Mine	35	35	140	160	370
191	Shiprock	Climax Transfer Station	1705	1705	70	160	3640
192	Red Valley	East Mesa Mines	0	0	120	160	280
194	Cove	West Mesa Mine	0	0	90	160	250
194	Red Valley	Cove Transfer Station	2020	2020	340	160	4540

Table 4. Combined Pathway Score (continued).

MAP-ID	Chapters	Mine Name / Identifier	Total Soil Score	Total Air Score	Total Groundwater Score	Total Surface Water Score	Combined Score
195	Round Rock	Mexican Cry Mine	0	0	30	160	190
196	Round Rock	Mexican Cry Mine	0	0	30	160	190
197	Round Rock	Hall Mine	0	0	30	160	190
198	Round Rock	Cov198	0	0	30	160	190
199	Round Rock	Nakai Chee Begay Mine	0	0	30	160	190
200	Cove	Cato No. 2	10	10	130	160	310
201	Cove	Cato No. 1 Pit	330	330	130	160	950
202	Cove	Frank Jr. Mine	60	60	120	160	400
203	Cove	NA-0319	20	20	120	160	320
204	Cove	Mesa VI Mine	20	20	160	160	360
205	Cove	NA-0319	20	20	160	160	360
206	Cove	Mesa V Adit	0	0	120	160	280
207	Cove	Mesa V Incline	0	0	120	160	280
208	Cove	Mesa V Mine	0	0	160	160	320
209	Cove	Mesa V Mine	20	20	160	160	360
210	Cove	NA-0318	0	0	120	160	280
211	Cove	Cov087	20	20	160	160	360
212	Cove	Mesa IV 1/2 Mine	20	20	160	160	360
213	Cove	North Portal, Frank No. 1 Mine	20	20	160	160	360
214	Cove	East Portal, Frank No. 1 Mine	20	20	160	160	360
215	Cove	Frank No. 2	20	20	150	160	350
216	Cove	South Portal, Frank No. 1 Mine	20	20	130	160	330
217	Cove	NA-0316	20	20	130	160	330
218	Cove	Cov068	0	0	120	160	280
219	Cove	Mesa IV, Mine No. 2	0	0	120	160	280
220	Cove	Mesa IV, Mine No. 3	0	0	120	160	280
221	Cove	Mesa IV, Mine No. 1	10	10	120	160	300
222	Cove	Mesa II Pit	0	0	120	160	280
223	Cove	Mesa IV 1/4 Mine	20	20	130	160	330
224	Cove	Mesa IV, West Mine	30	30	120	160	340
225	Cove	Mesa I Mine 11	0	0	100	160	260
226	Cove	Mesa I Mine 15	0	0	110	160	270
227	Cove	Mesa I Mine 10	0	0	140	160	300
228	Cove	Mesa I Mine 13	0	0	140	160	300
229	Cove	Mesa I Mine 12	0	0	100	160	260
230	Cove	Mesa I Mine 14	0	0	70	160	230
231	Round Rock	Jimmie King No. 9 Mine	0	0	30	160	190
232	Cove	Mesa IV, East Side	10	10	70	160	250
233	Cove	Mesa III, Northwest Mine	25	25	70	160	280
234	Cove	Cov000	10	10	70	160	250
235	Cove	Mesa III, West Mine	25	25	80	160	290
236	Cove	Mesa III Mine	25	25	70	160	280
237	Cove	Mesa II 1/2, Mine 4	25	25	70	160	280
238	Cove	Mesa II 1/2 Mine	10	10	70	160	250
239	Cove	NA-0313	10	10	70	160	250
240	Cove	Mesa II 1/4 Mine	10	10	70	160	250
241	Cove	Mesa II, Mine 4	0	0	70	160	230
242	Cove	Henry Phillips Mine	0	0	70	160	230
243	Cove	Mesa I 1/2 Mine	0	0	60	160	220
244	Cove	Mesa II, Mine No. 1, P-150	10	10	70	160	250
245	Cove	Mesa II, Mine No. 1 & 2, P-21	10	10	70	160	250
246	Cove	Mesa I 3/4, Mine No. 2, P150	10	10	70	160	250
247	Cove	Mesa I 1/2, West Mine	0	0	60	160	220
248	Cove	Mesa I 1/4 Mine	30	30	100	160	320
249	Round Rock	NA-0333	0	0	40	160	200
250	Round Rock	NA-0332	0	0	40	160	200
251	Round Rock	Tommy James Mine	0	0	50	160	210
252	Round Rock	Step Mesa Mine	0	0	60	160	220
253	Cove	Mesa I 3/4 Incline	0	0	80	160	240
254	Round Rock	Flag No. 1 Mine	0	0	70	160	230
255	Round Rock	Black No. 1 Mine	0	0	60	160	220
256	Round Rock	Black No. 2 Mine (West)	0	0	50	160	210
257	Round Rock	Black No. 2 Mine	0	0	50	160	210
258	Cove	Billy Topaha Mine	0	0	50	160	210
259	Round Rock	Joleo Mine	0	0	50	160	210
260	Round Rock	Cisco Mine	0	0	50	160	210
261	Round Rock	Camp Mine	0	0	40	160	200
262	Round Rock	Knife Edge Mesa Mine	0	0	60	160	220
263	Round Rock	NA-0343	0	0	60	160	220
264	Red Valley	Rocky Spring Mine	330	330	150	160	970
265	Red Valley	H. B. Roy No. 1	0	0	30	160	190
266	Sanostee	Key and Tohe	20	20	20	160	220
267	Sanostee	Castle Tsosie	0	0	10	160	170
268	Sanostee	Joe Ben 1	0	0	10	160	170
269	Sanostee	Joe Ben 2	0	0	10	160	170
270	Sanostee	Deneh Nezz 3	0	0	10	160	170
271	Sanostee	Deneh Nezz 1, 2	0	0	10	160	170
272	Sanostee	Enos Johnson Claim?	0	0	10	160	170
273	Sanostee	John Joe 1	0	0	10	160	170
274	Sanostee	Enos Johnson	0	0	10	160	170
275	Sanostee	Enos Johnson	0	0	10	160	170
276	Sanostee	Joe Ben 3	0	0	10	160	170
277	Sanostee	NA-0603	0	0	10	160	170
278	Sanostee	Enos Johnson 3	0	0	10	160	170
279	Sanostee	Enos Johnson 1, Enos Johnson 2	0	0	10	160	170
280	Sanostee	Enos Johnson	0	0	10	160	170
281	Sanostee	Enos Johnson	0	0	10	160	170
282	Sanostee	Horace Ben	0	0	10	160	170
283	Sanostee	Carl Yazzie 1	0	0	10	160	170
284	Sanostee	H. B. Roy No. 2	10	10	10	160	190
285	Sanostee	Reed Henderson	0	0	0	160	160



ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - MAP INDEX

Sources

Uranium mine areas are primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by other sources. The Navajo Nation and Chapter boundaries are from the Navajo Lands Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Buffers were generated by TerraSpectra Geomatics. Map index area boundaries are approximate.

Map Index Area Designations

Figure		Figure	
7 -	North Central Aneth	13 -	Southwest Sweetwater
8 -	Northwest Red Mesa	14 -	West Carrizo
9 -	North Teec Nos Pos	15 -	East Carrizo
10 -	South Red Mesa	16 -	Shiprock
11 -	Tse Tah	17 -	Lukachukai
12 -	Northeast Carrizo	18 -	Chuska

N E S W

0 20 Miles

Map Scale 1:600,000

Legend

Northern AUM Region

Uranium Mine

Mine Buffers

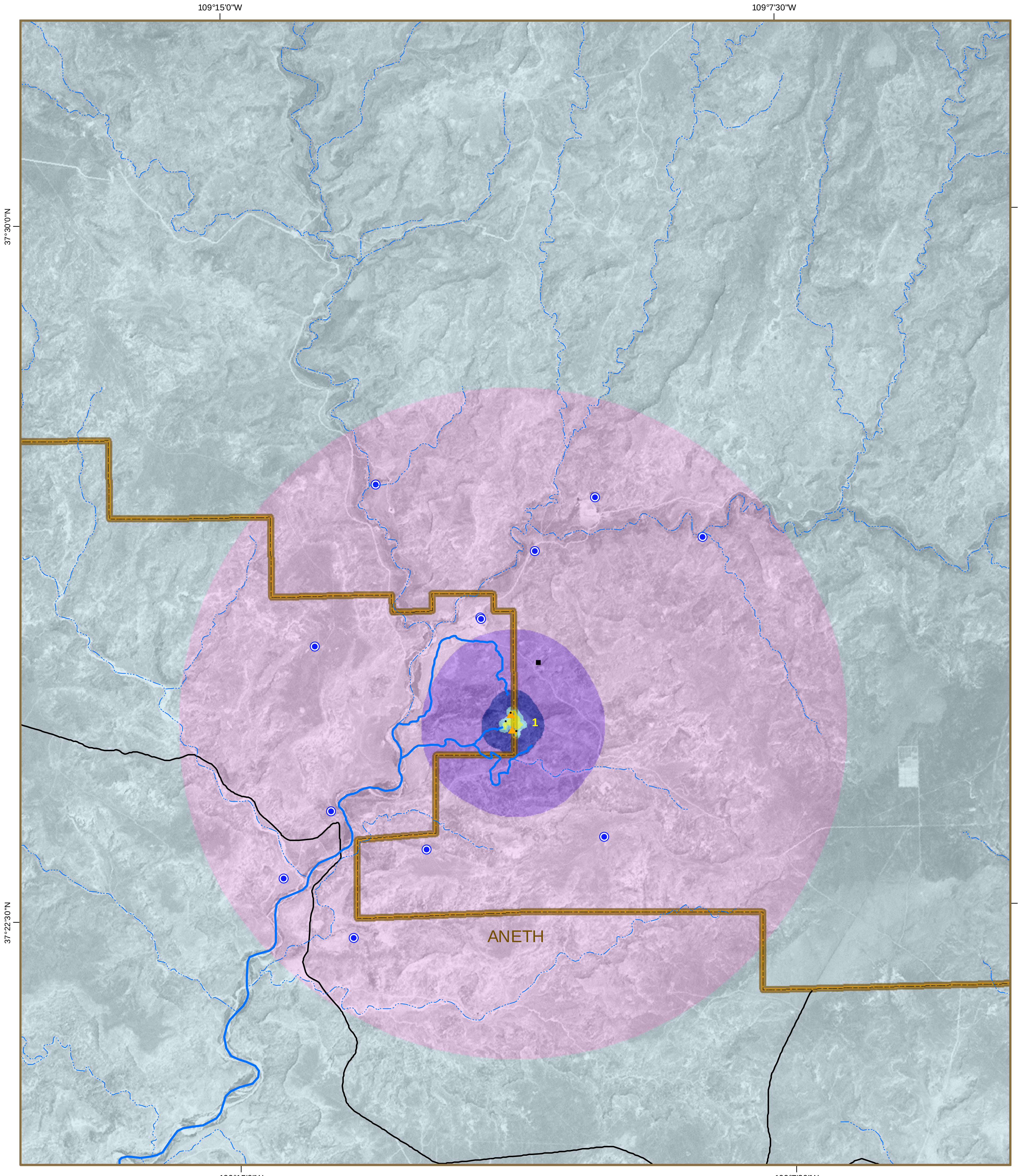
1/4 Mile

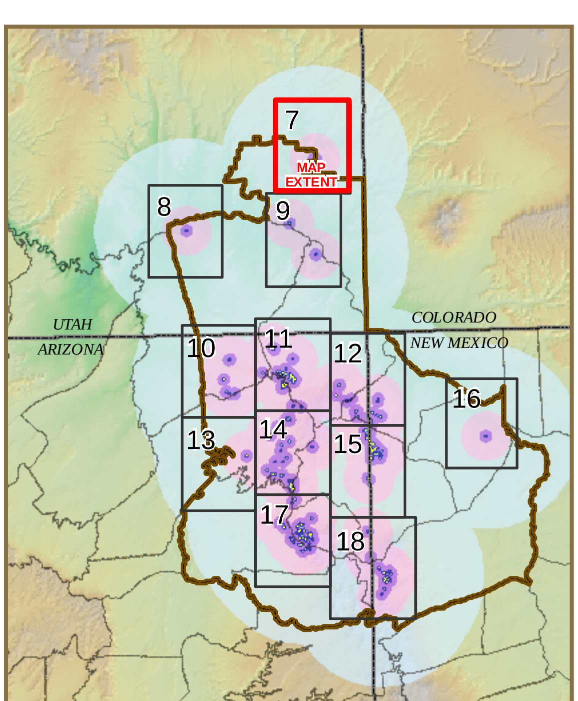
1 Mile

4 Miles

15 Miles

Figure 6. Combined Pathways Map Index.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - NORTH CENTRAL ANETH

N
W E
S

0 4 Miles

Map Scale 1:80,000

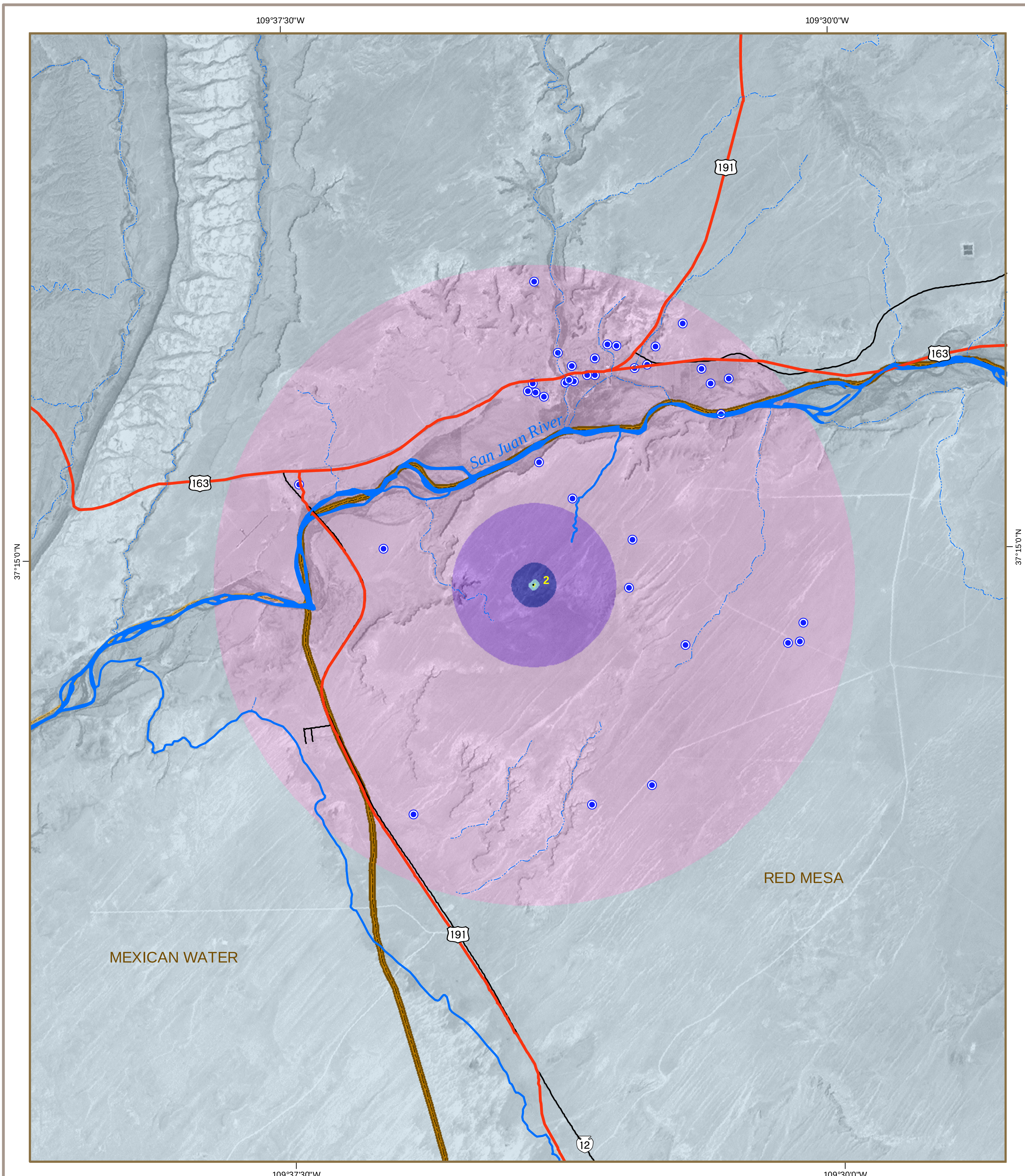
Legend

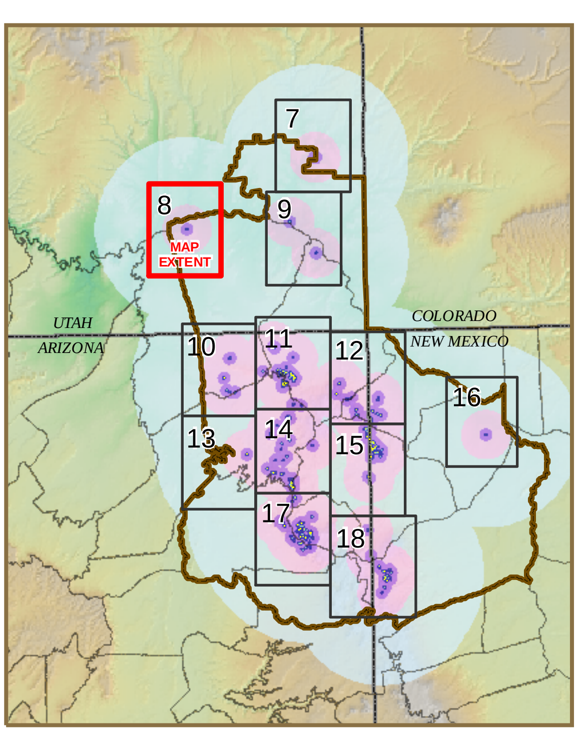
- MAP-ID
- Mine Feature
- CERCLIS Project
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- Highway
- Paved Road
- Uranium Mine

Mine Buffers

- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 7. Combined Pathways in the North Central Aneth Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - NORTHWEST RED MESA

0 4 Miles

Map Scale 1:80,000

Legend

MAP-ID

Mine Feature

Structure within 1 Mile

Well within 4 Miles

Downstream Water Pathway

Perennial Stream

Intermittent Stream

Northern AUM Region

Chapter

Highway

Paved Road

Uranium Mine

Mine Buffers

200 Feet

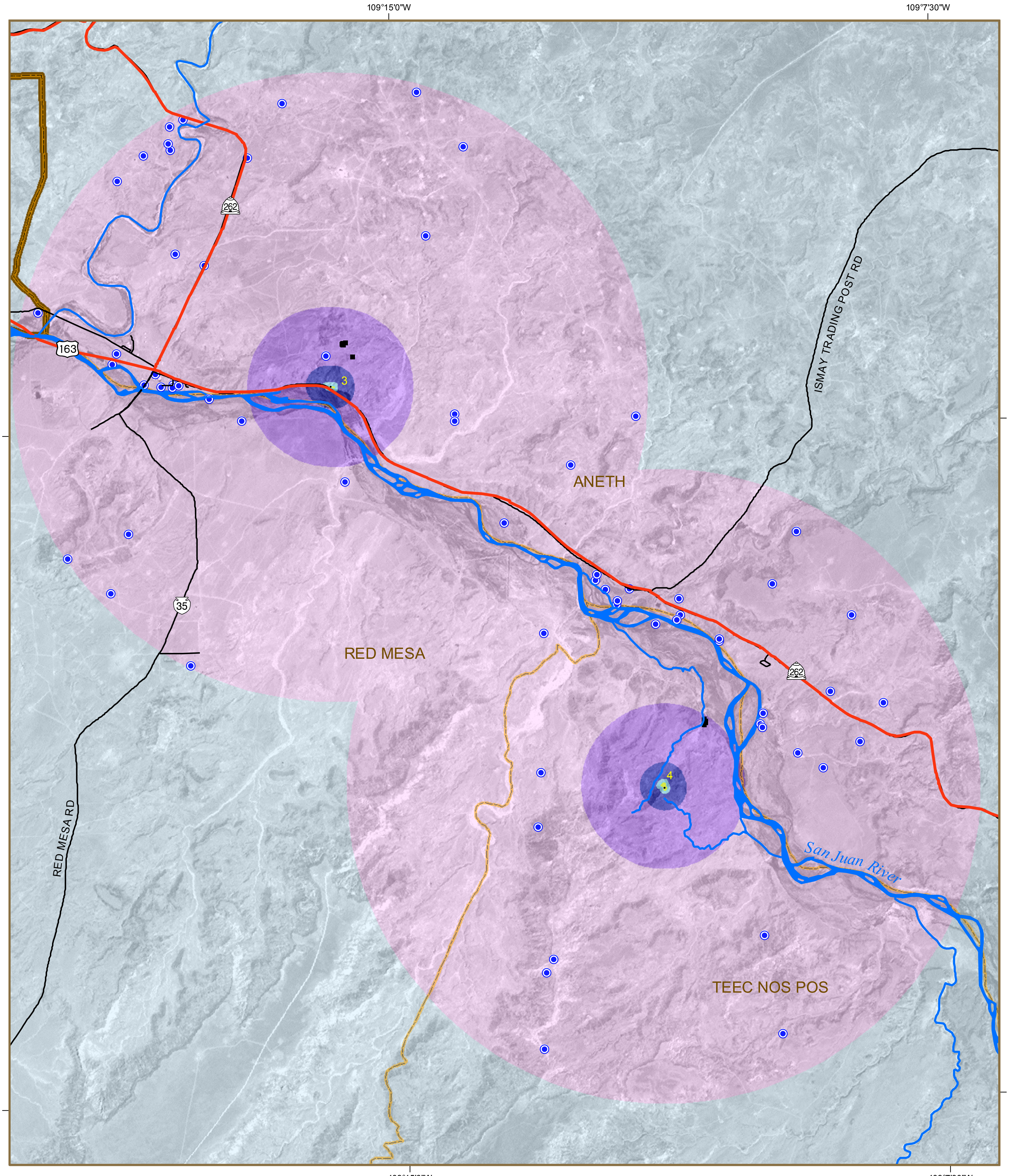
1/4 Mile

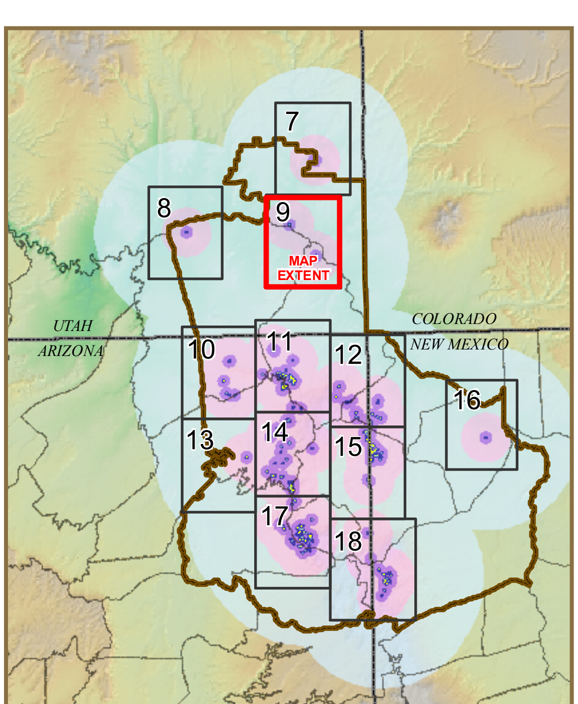
1 Mile

4 Miles

15 Miles

Figure 8. Combined Pathways in the Northwest Red Mesa Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - NORTH TEEC NOS POS

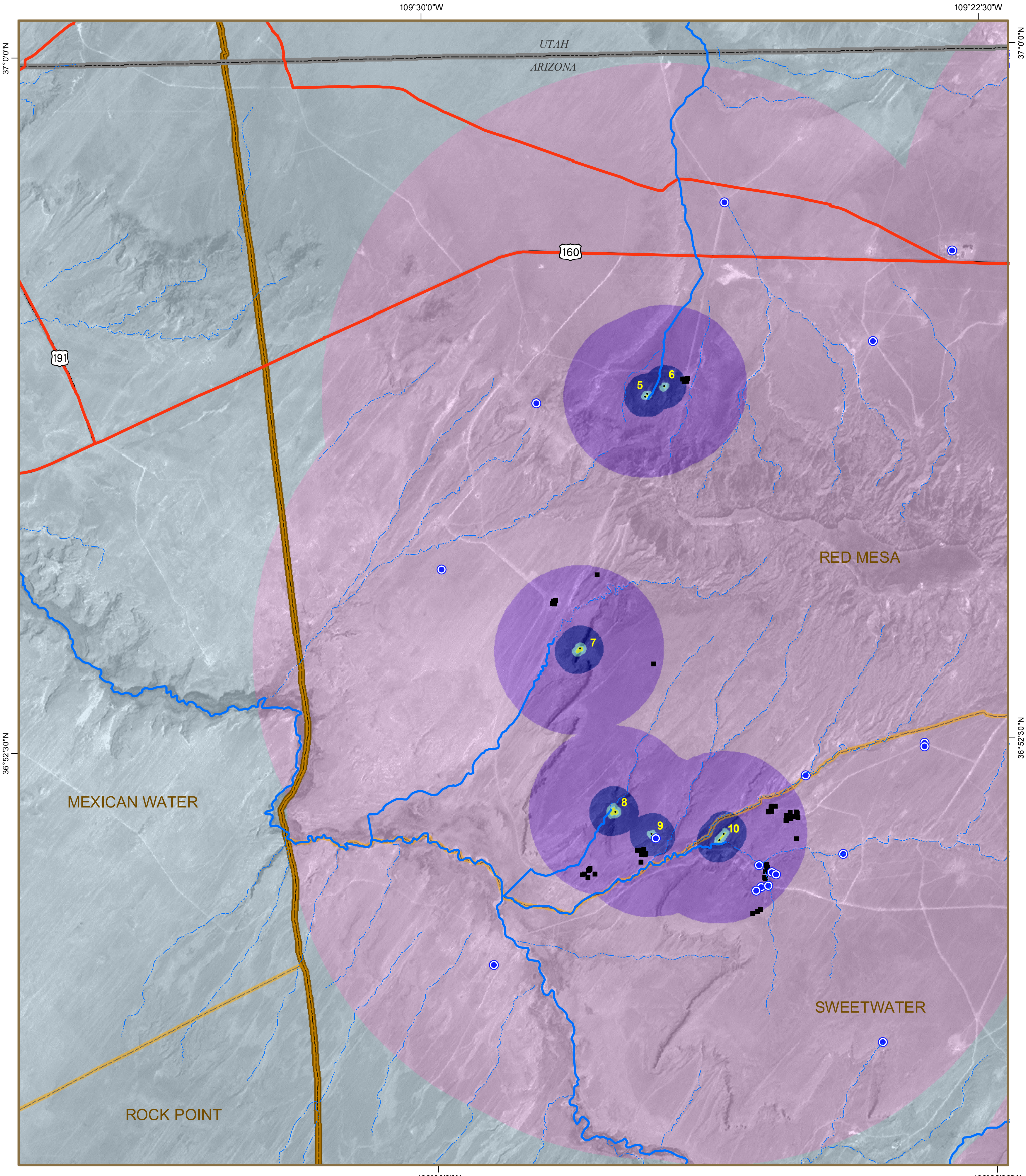
0 4 Miles

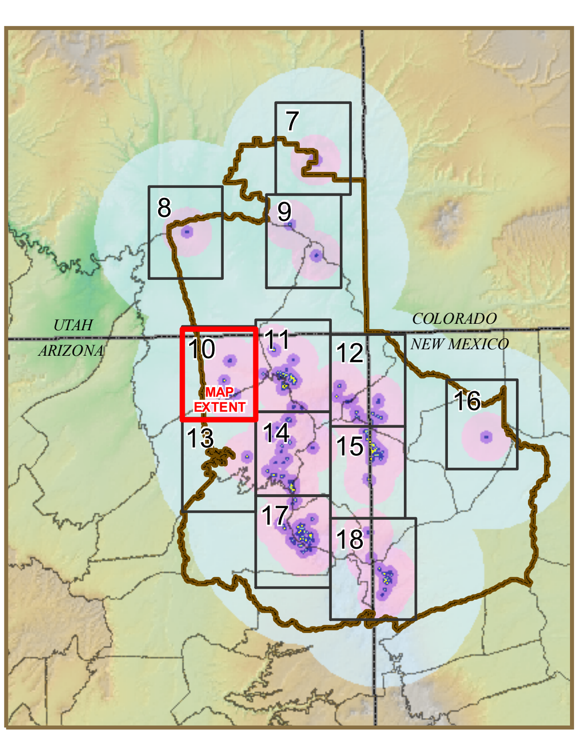
Map Scale 1:82,500

Legend

- 3 MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- Highway
- Paved Road
- Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 9. Combined Pathways in the North Teec Nos Pos Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - SOUTH RED MESA

N
W E
S

0 4 Miles

Map Scale 1:80,000

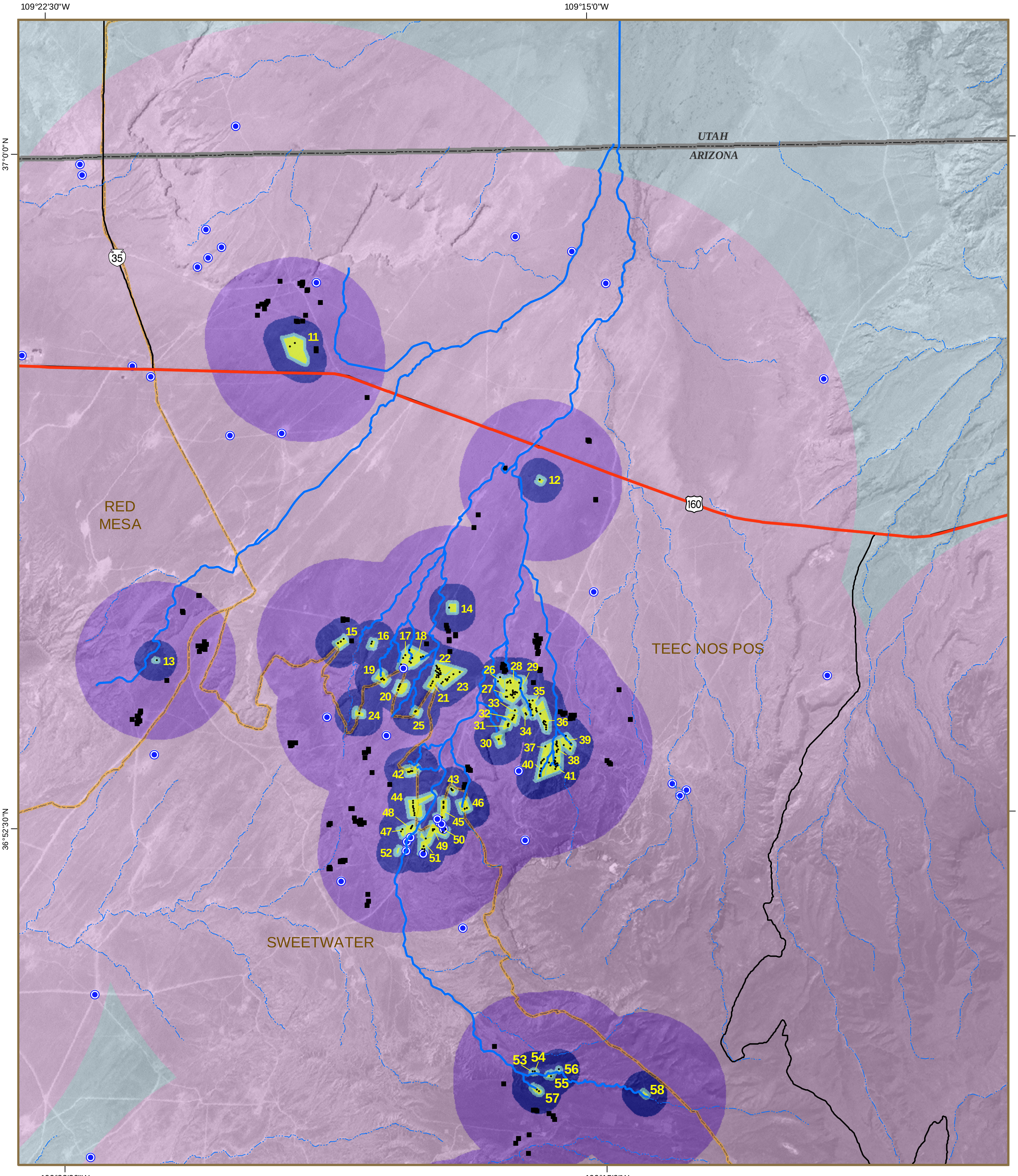
Legend

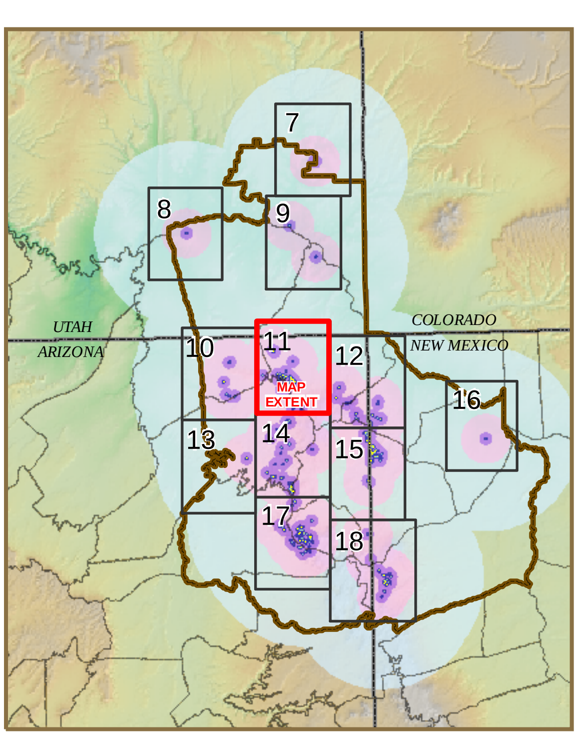
- 5 MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- State
- Highway
- Paved Road
- Uranium Mine

Mine Buffers

- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 10. Combined Pathways in the South Red Mesa Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - TSE TAH

0 4 Miles

Map Scale 1:82,500

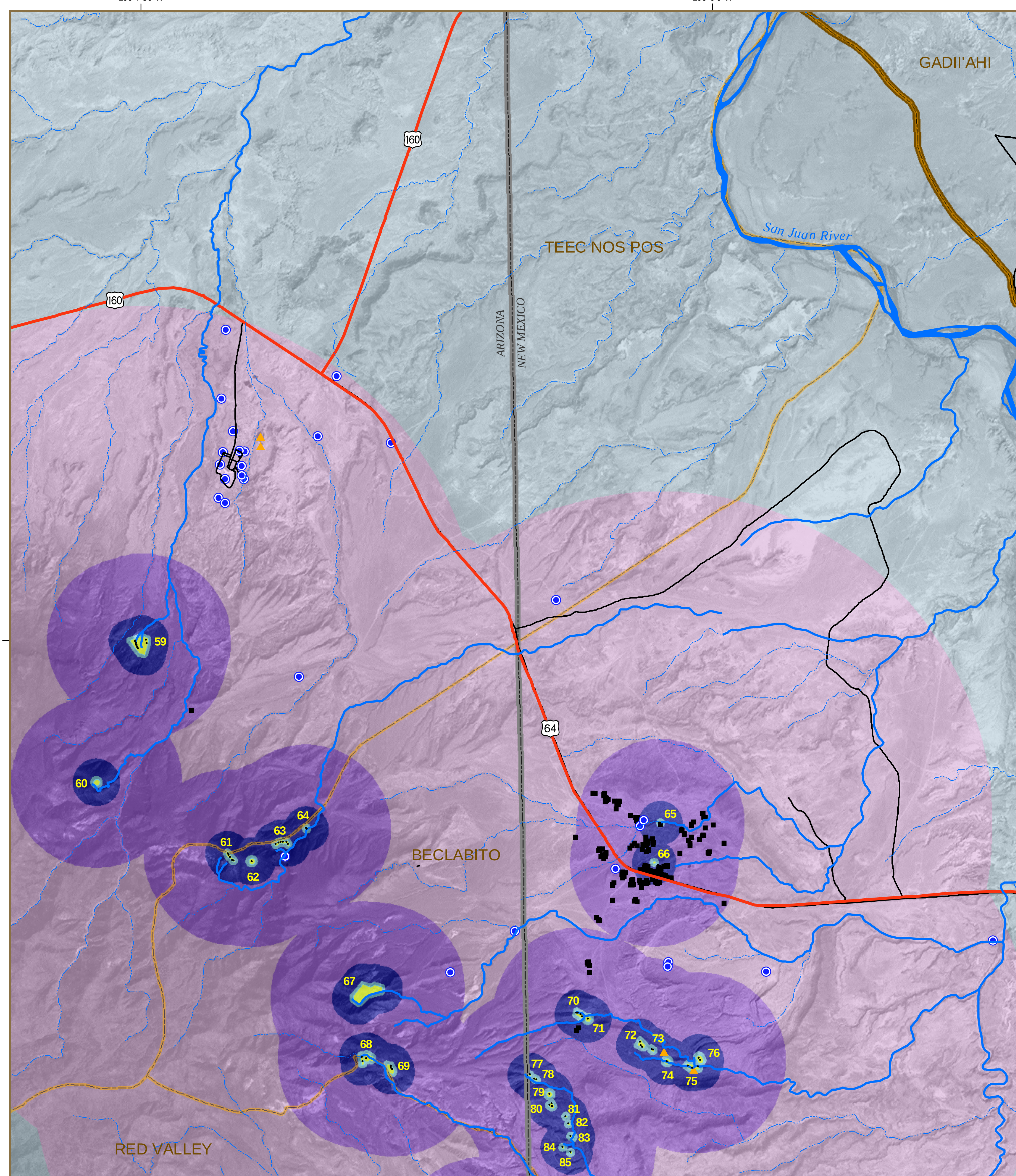
Legend

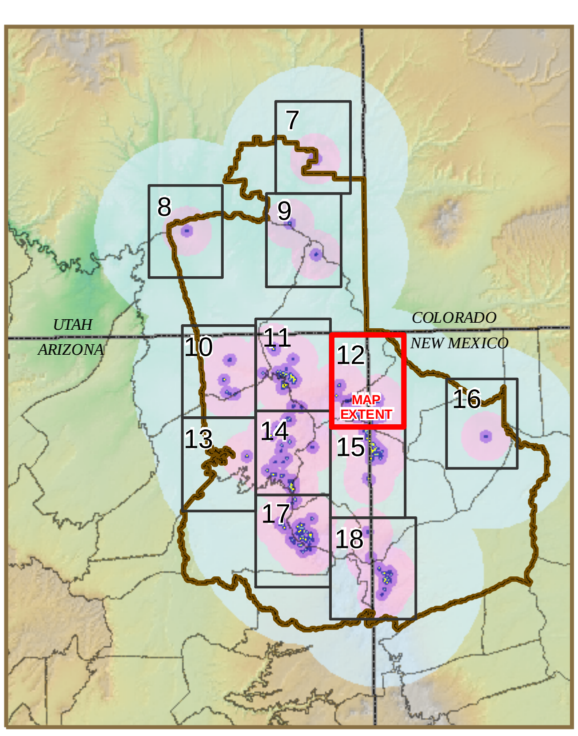
- 11 MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- State
- Highway
- Paved Road
- Uranium Mine

Mine Buffers

- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 11. Combined Pathways in the Tse Tah Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - NORTHEAST CARRIZO

0 4 Miles

Map Scale 1:80,000

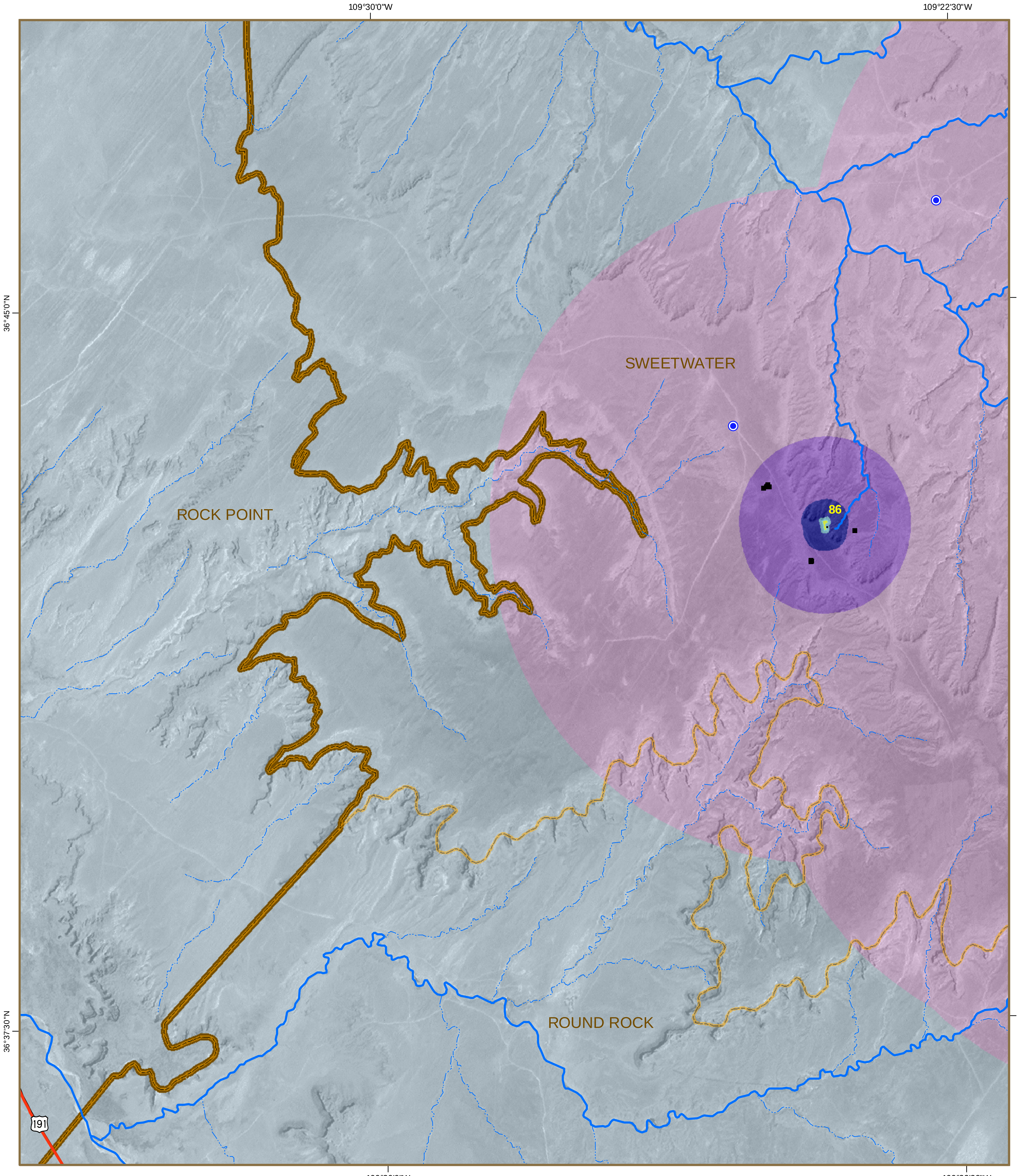
Legend

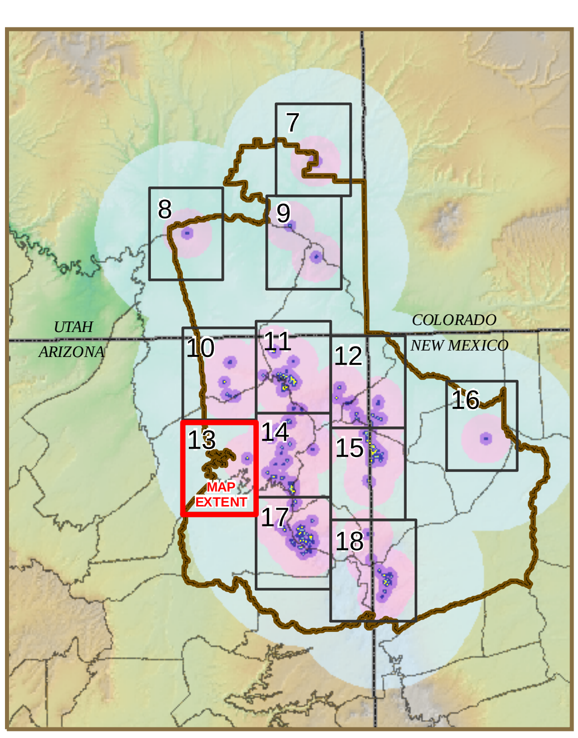
- 59 MAP-ID
- Mine Feature
- CERCLIS Project
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- State
- Highway
- Paved Road
- Uranium Mine

Mine Buffers

- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 12. Combined Pathways in the Northeast Carrizo Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - SOUTHWEST SWEETWATER

N
W E
S

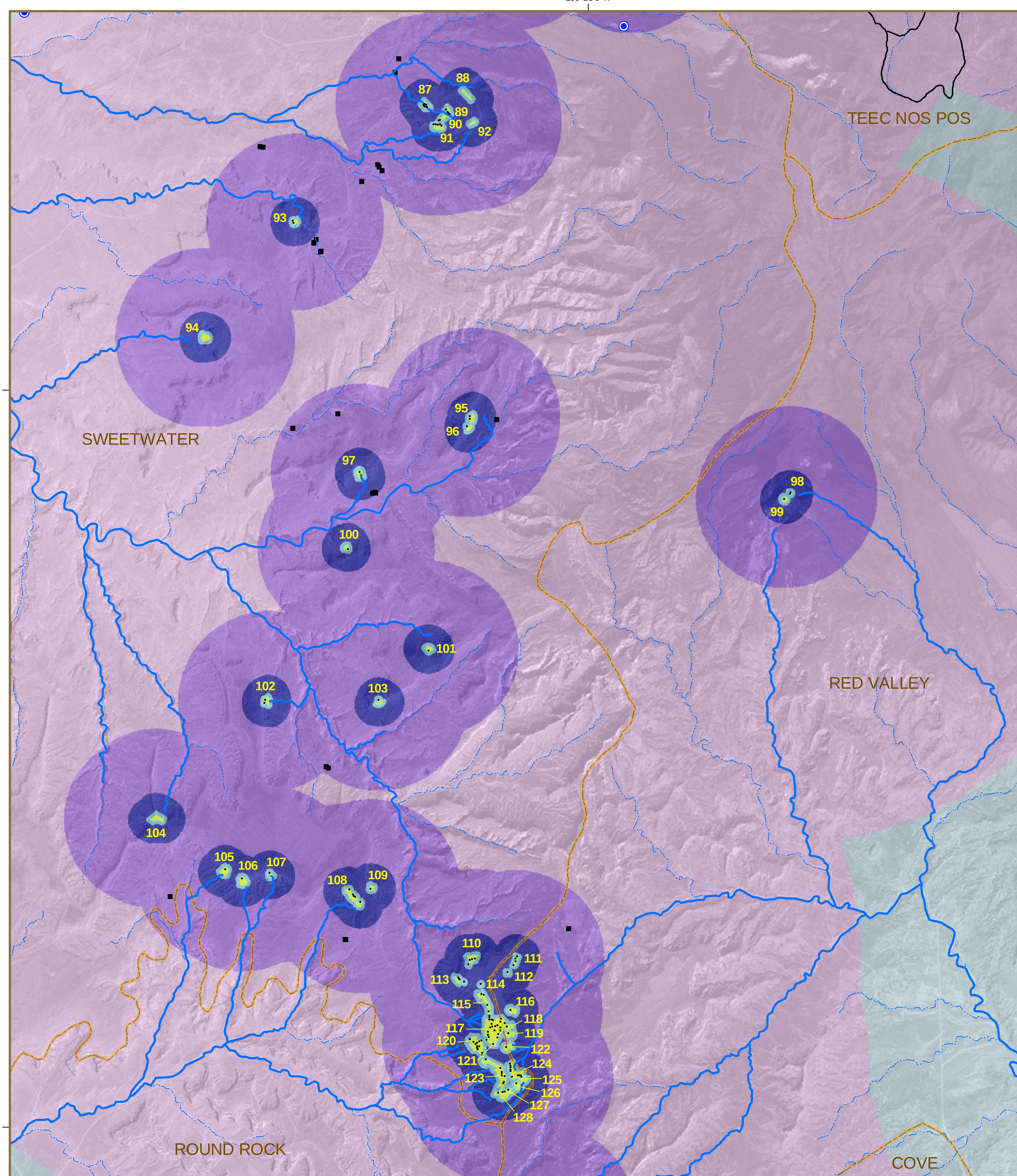
0 4 Miles

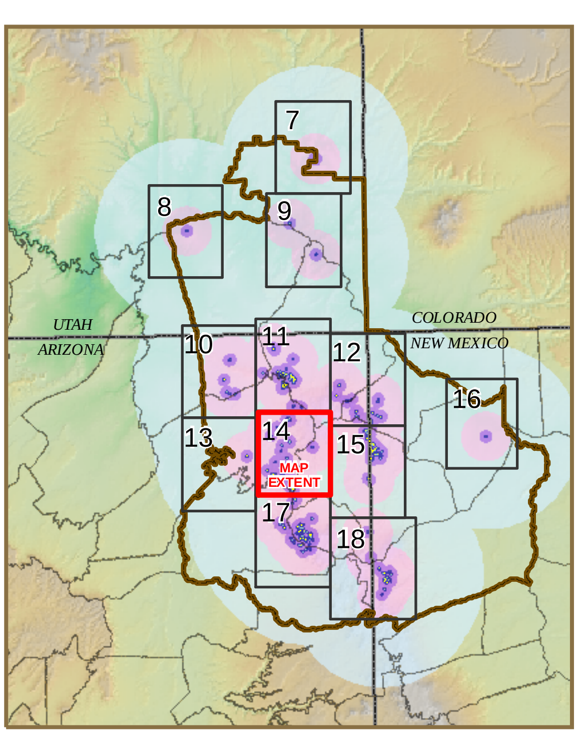
Map Scale 1:77,500

Legend

86 MAP-ID	Downstream Water Pathway	Uranium Mine
Mine Feature	Perennial Stream	Mine Buffers
Structure within 1 Mile	Intermittent Stream	200 Feet
Well within 4 Miles	Northern AUM Region	1/4 Mile
	Chapter	1 Mile
	Highway	4 Miles
	Paved Road	15 Miles

Figure 13. Combined Pathways in the Southwest Sweetwater Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - WEST CARRIZO

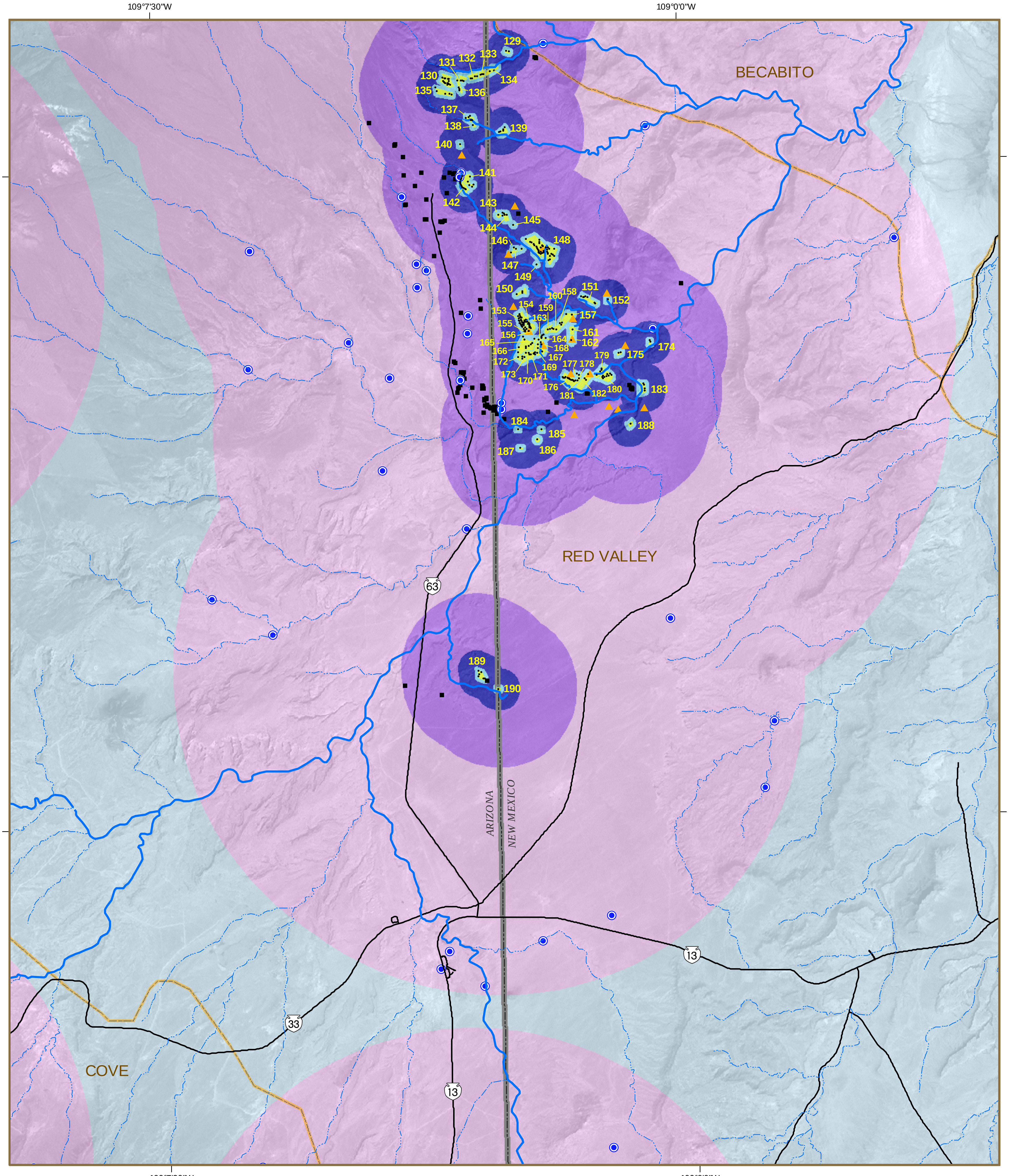
0 4 Miles

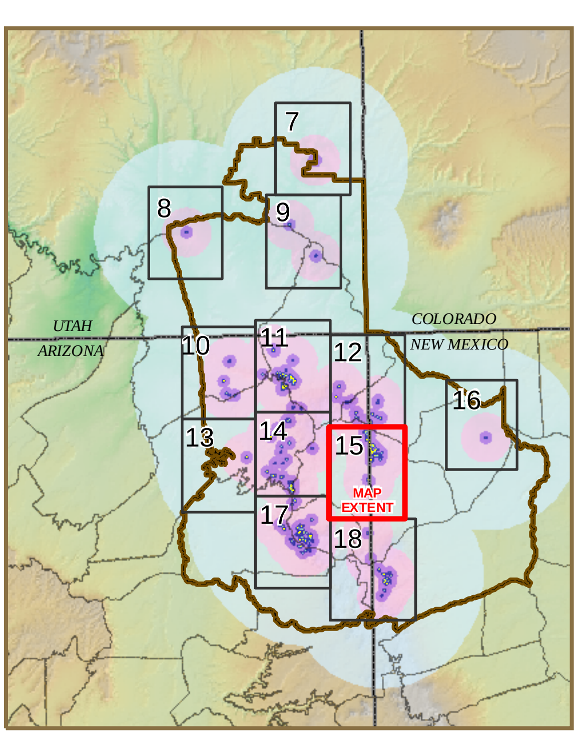
Map Scale 1:77,500

Legend

- 87 MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- Highway
- Paved Road
- Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 14. Combined Pathways in the West Carrizo Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - EAST CARRIZO

0 4 Miles

Map Scale 1:85,000

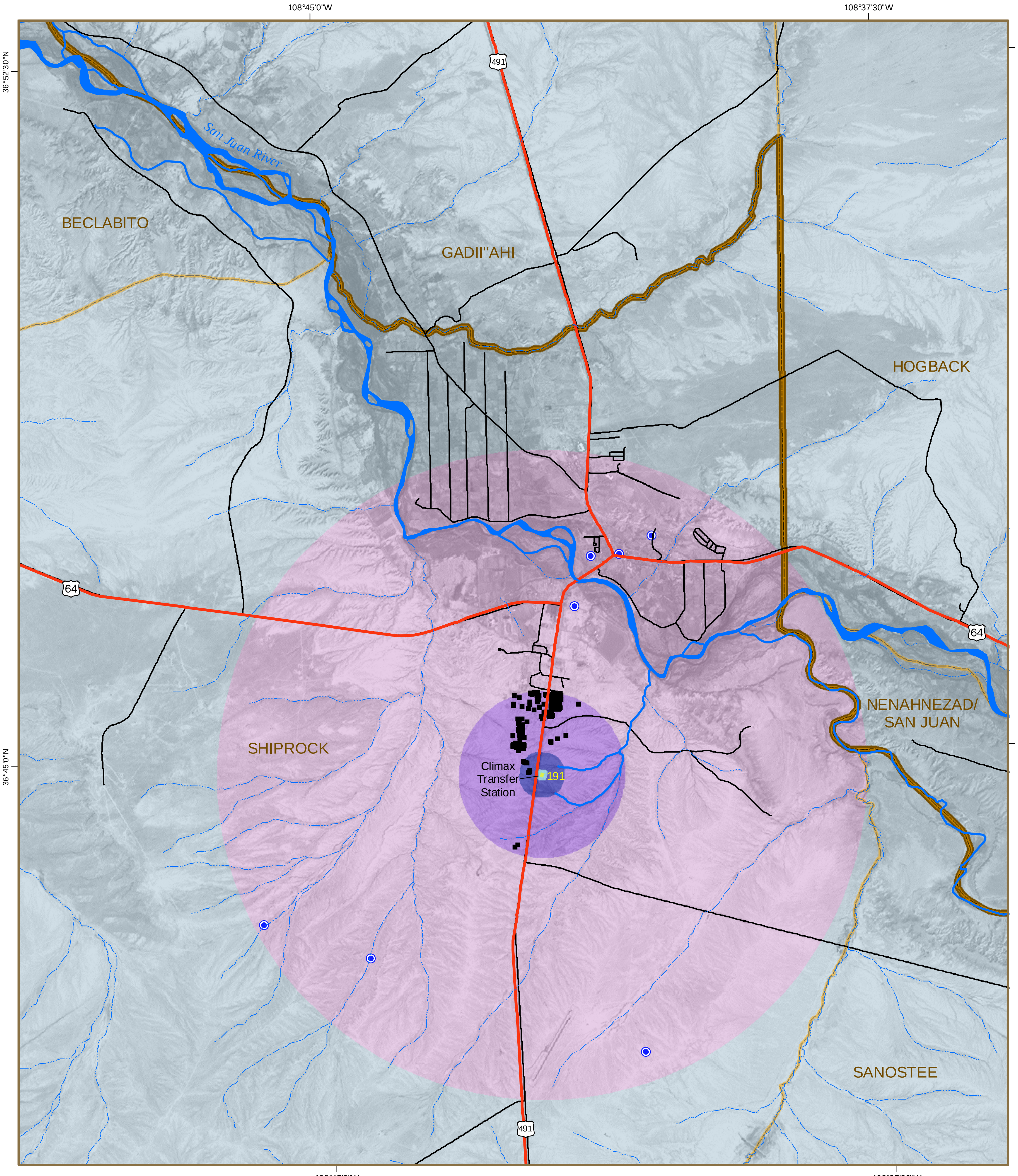
Legend

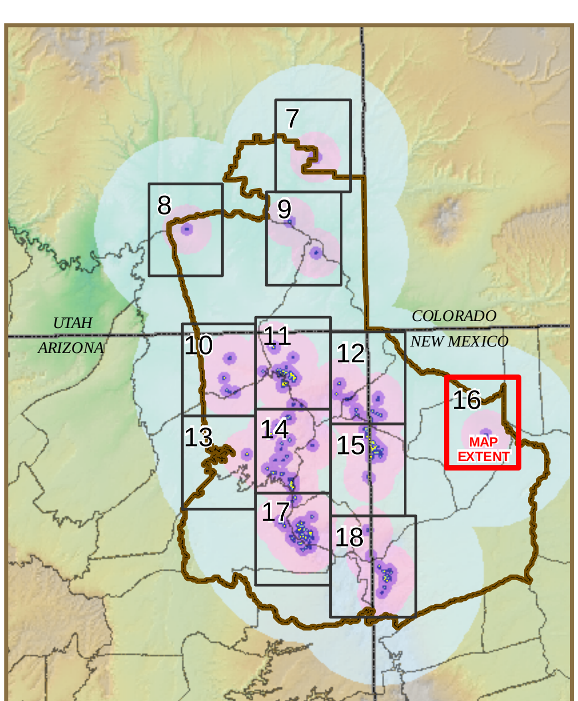
- 129 MAP-ID
- Mine Feature
- CERCLIS Project
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- Chapter
- Highway
- Paved Road
- Uranium Mine

Mine Buffers

- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 15. Combined Pathways in the East Carrizo Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - SHIPROCK

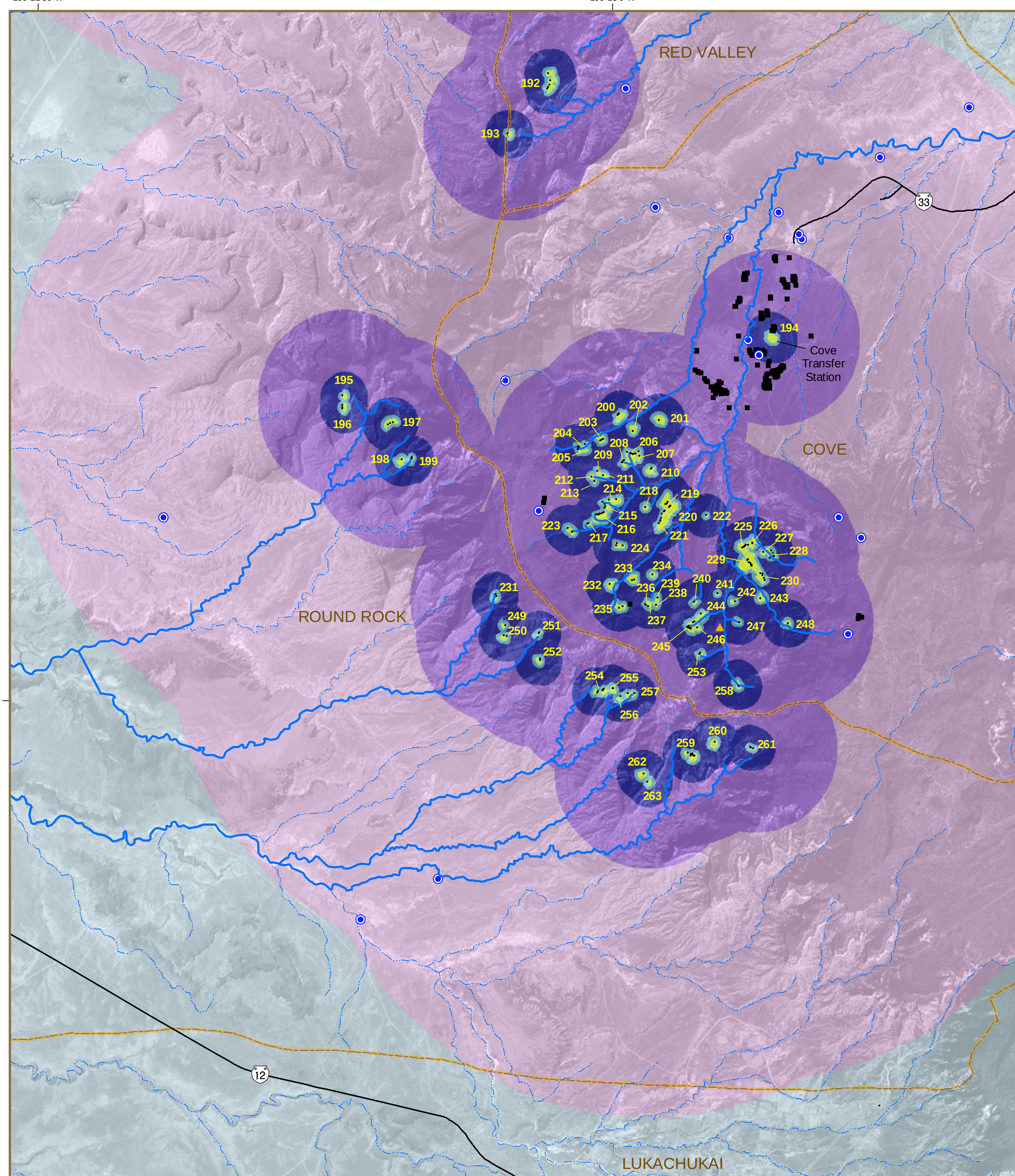
0 4 Miles

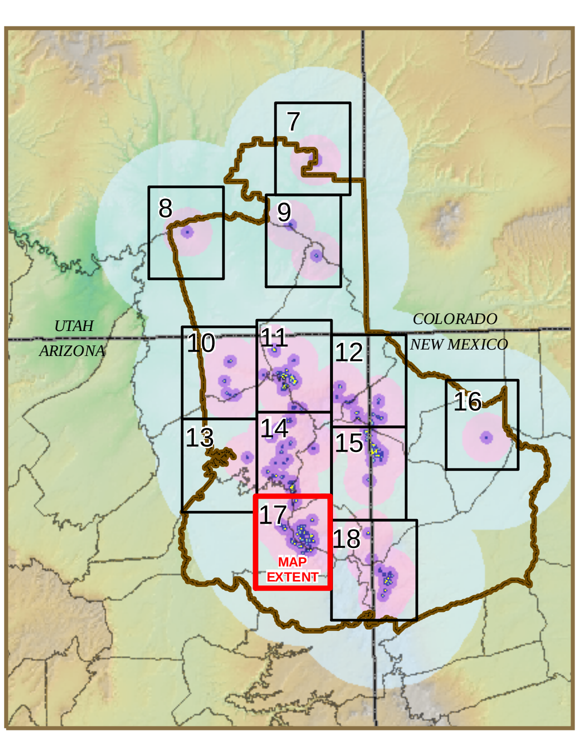
Map Scale 1:80,000

Legend

191 MAP-ID	Downstream Water Pathway	Uranium Mine
Mine Feature	Perennial Stream	Mine Buffers
Structure within 1 Mile	Intermittent Stream	200 Feet
Well within 4 Miles	Northern AUM Region	1/4 Mile
	Chapter	1 Mile
	Highway	4 Miles
	Paved Road	15 Miles

Figure 16. Combined Pathways in the Shiprock Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - LUKACHUKAI

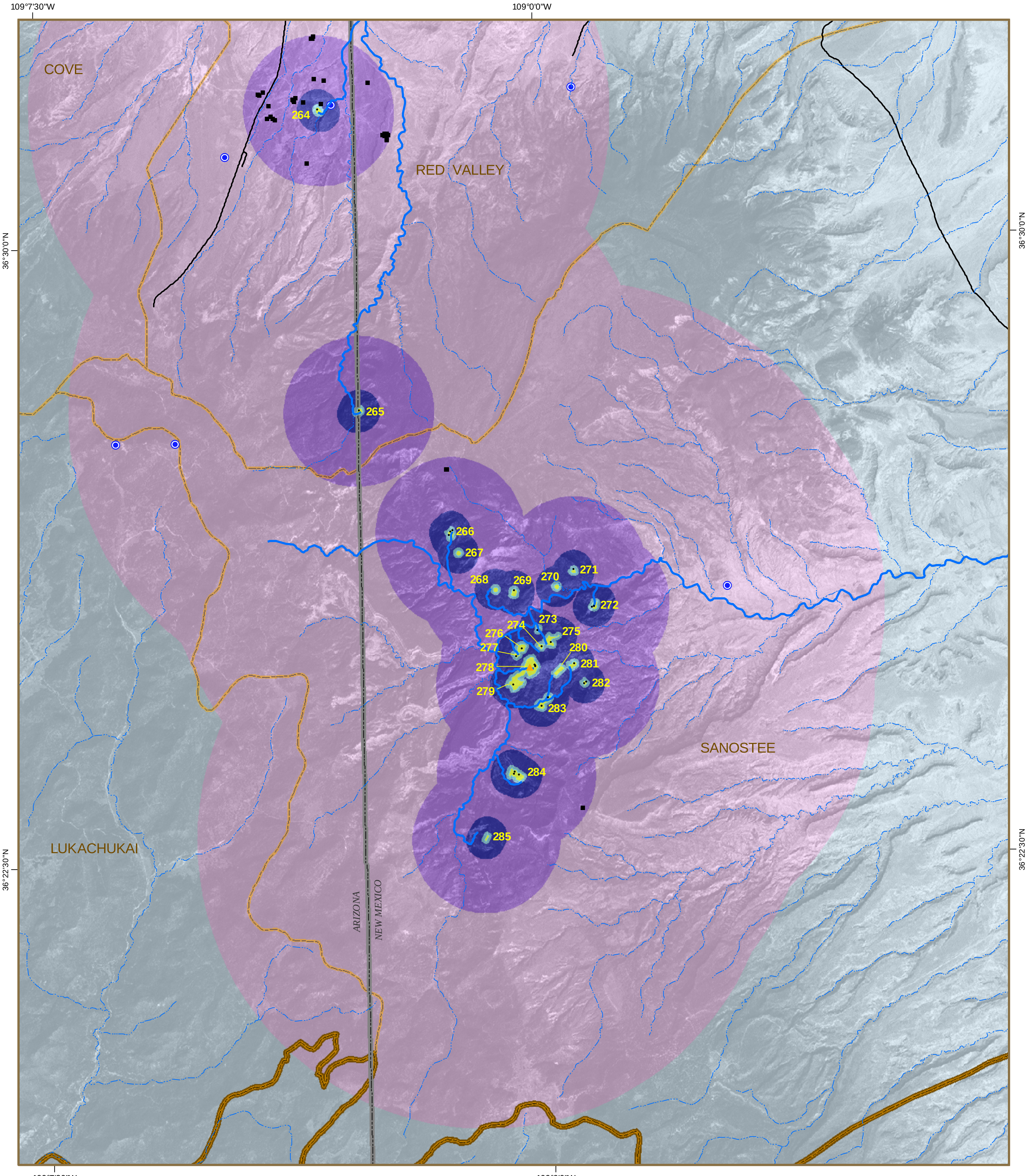
0 4 Miles

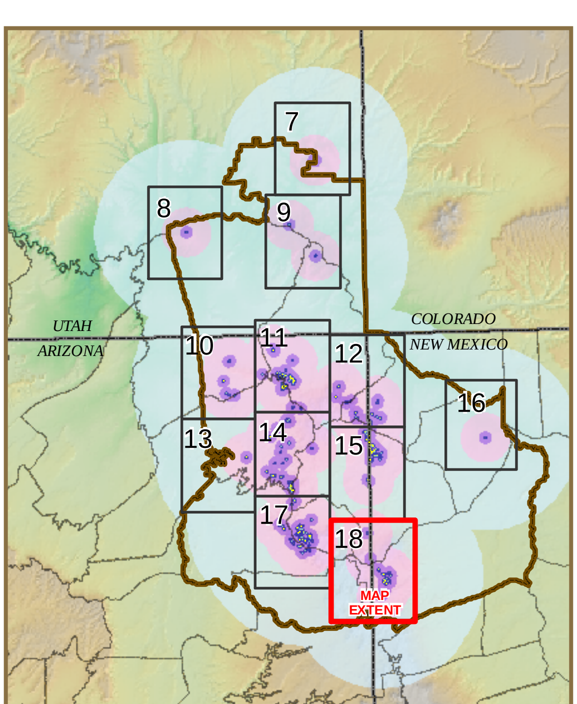
Map Scale 1:80,000

Legend

192 MAP-ID	Downstream Water Pathway	Uranium Mine
Mine Feature	Perennial Stream	Mine Buffers
CERCLIS Project	Intermittent Stream	200 Feet
Structure within 1 Mile	Northern AUM Region	1/4 Mile
Well within 4 Miles	Chapter	1 Mile
	Highway	4 Miles
	Paved Road	15 Miles

Figure 17. Combined Pathways in the Lukachukai Region.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - CHUSKA

0 4 Miles

Map Scale 1:90,000

Legend

- 264 MAP-ID
- Mine Feature
- CERCLIS Project
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- State
- Highway
- Paved Road
- Uranium Mine

Mine Buffers

- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 18. Combined Pathways in the Chuska Region.

DISCUSSION

Results from the HRS-derived screening model allowed the development of a scored AUM site list for the Northern AUM Region. As noted earlier, the scoring is not intended to identify actual risks, but is meant to provide a coarse screening of priority AUM sites for further investigation. The GIS approach facilitated a consistent and documented scoring process. The GIS cartographic tools also allowed flexible visualization of the data and analysis results.

Review of the Combined Pathway Scores (Table 4) and Figure 20 "Combined Pathway - Three Score Ranges" show that the highest scoring AUM sites occur in the Northeast Carrizo mining area of the Beclabito Chapter (NA-0420 and NA-0424), the Lukachukai mining area of Cove Chapter (Cove Transfer Station), and the Climax Transfer Station south of the Shiprock community. NA-0420 and NA-0424 are AUM sites that were reclaimed by the NAMLRP. NA-0420 is identified as a rim strip/pit feature, and NA-0424 is identified as a prospect. Uranium/vanadium historical records could not be located for either of these sites. The Cove Transfer Station was not an AUM, but was used as a stockpile site. Uranium ore was trucked from the Mesa No. II mine to the Cove Camp, dumped at the stockpile, and loaded onto larger trucks and transported to the Shiprock mill (Dare, 1961). Historical records could not be found for the Climax Transfer Station (MAP-ID #191). William Chenoweth (written communication, 2006) identified the site as a stockpile for ore mined at the Frankie No. 1 Mine that was then transferred to the Climax Uranium Mill in Grand Junction. The Navajo Nation Environmental Protection Agency Superfund Program has recently conducted field assessments of the site (NNEPA, 2006).

Since the primary HRS criteria are counts of structures and wells at specified distances from the AUMs, areas with high occurrences of homes and wells proximal to the AUM sites scored high. Conversely, remote AUM sites with sparse population and wells score low. This can be seen in the generally low scores for the AUM sites in the Chuska, Lukachukai, southwest Sweetwater, west Carrizo and portions of the northeast Carrizo mining areas (shown in green on Figure 19).

Rocky Spring Mine in the Chuska mining area (MAP-ID #264) is an example of an AUM site that scored moderately high (970) due to proximity of homes and wells. However, this is an unreclaimed rim strip/pit site with limited production (a total of 11 tons of ore mined), and only 3 pounds of uranium and 62 pounds of vanadium extracted (Chenoweth, 1984). This is an insignificant production number compared to the Mesa II, Mine #1&2, P-21 AUM (MAP-ID #245) that scored 250 but had 274,128 tons of ore mined with 1,284,853 pounds of uranium and 5,475,210 pounds of vanadium extracted (Chenoweth, 1988).

As discussed under the METHODOLOGY section, the scores derived from this first stage of the model are only an indicator of potential risk, not actual risks. As such, it is only the first stage in the process of decision-making as to which sites are a priority for more information gathering. Since many of the mine features may have had their risk reduced by reclamation or removal, that information will also need to be included and evaluated.

RECOMMENDATIONS

The scores resulting from this CERCLA screening process identifies those sites EPA recommends to the Navajo Nation to "require further investigation." The level of subsequent investigation would depend on the status and current knowledge of the site. If there is no reliable data about the site, screening level field data would be advised to determine follow-up needs. If the mine site is already in EPA's CERCLIS database, the next step would be to proceed with the Preliminary Assessment/Site Inspection phase of the HRS process to determine NPL candidates. If it is determined that a response action is required at a site, then characterization (detailed site studies) would be appropriate. Site specific characterization priorities should be established based on Navajo Nation priorities, AUM screening scores, resources, and site specific factors.

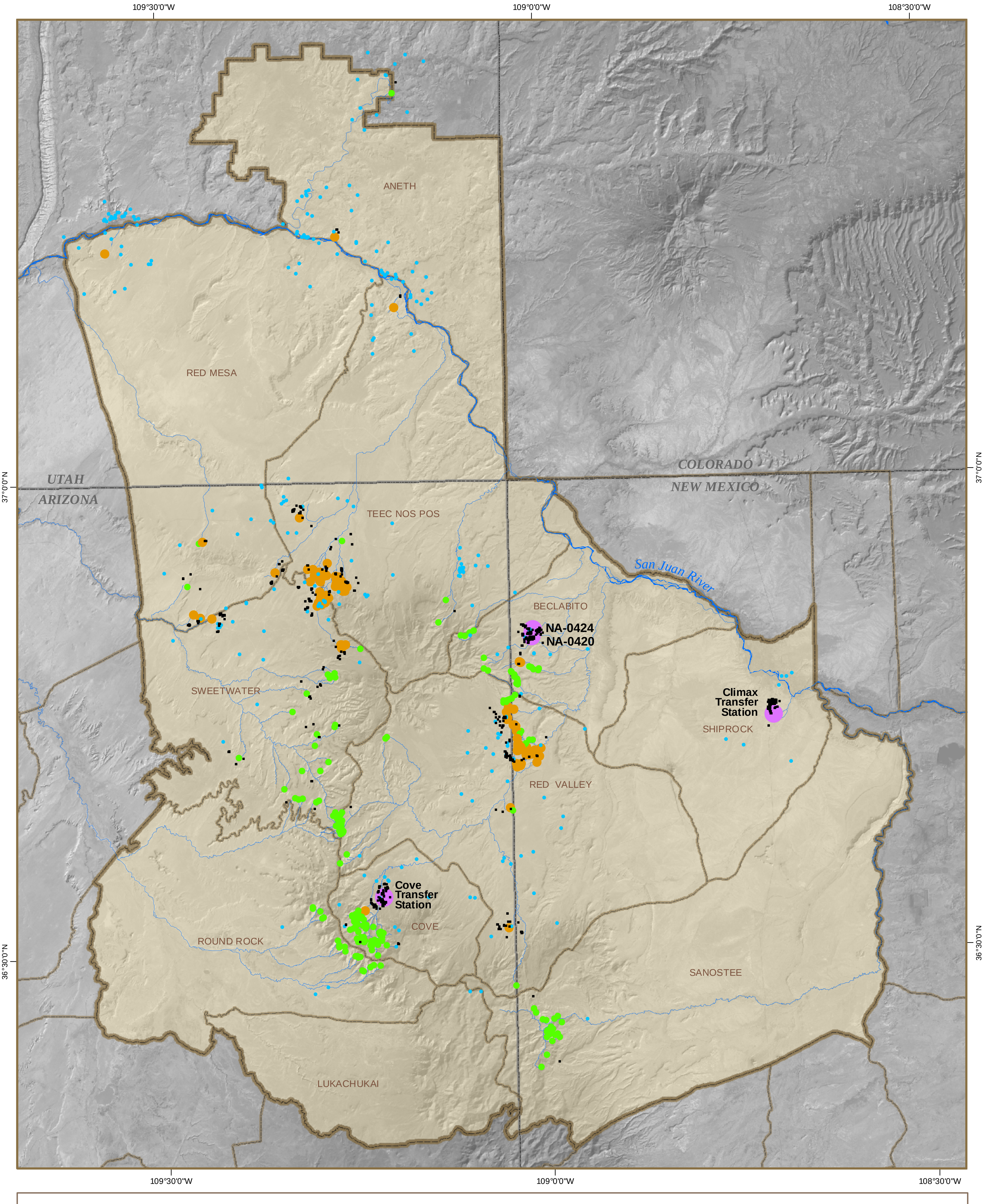
Screening assessments at mine sites commonly require evaluation of exposures from multiple sources and exposures via multiple pathways (EPA, 2000a). The modified HRS model used for this study was developed for the purpose of performing a coarse screening based on the presence of surface water drainages and the numbers of structures and wells proximal to AUM sites. Using existing GIS datasets, or by automating readily available data for the entire Navajo Nation, it may be possible to improve the analysis to better assess priority areas for further investigation. The following provides a list of existing or available datasets that could be used to develop additional factors that consider waste characteristics, likely transport pathways, and ecological targets.

- HRS factors related to uranium mine waste characteristics:
    - AUM reclamation sites with associated unreclaimed mine debris piles
    - Reclaimed AUM sites compared to AUM sites determined by NAMLRP to have insufficient risk for reclamation
    - Total uranium production for each mine
    - Bismuth-214 radiation data as an indicator of uranium concentrations
    - Host geologic formations for uranium ore
    - Water or stream sediment samples

- HRS factors related to pathways and likelihood of release:
    - Precipitation
    - Aquifer sensitivity
    - Intersections of surface water pathway buffers with downstream targets

- HRS factors related to targets:
    - Natural springs (undeveloped)
    - Sensitive habitats
    - Agricultural fields

EPA recommends a thorough review of available information prior to additional field investigations. Much of the available data and historic reports have already been provided to the NNEPA. A complete archive is also available in the Navajo Abandoned Uranium Mines Project files located in the EPA San Francisco Superfund Records Center.



ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

COMBINED PATHWAYS - THREE SCORE RANGES

Sources

Abandoned Uranium Mines (AUM) locations are primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by other sources. The Navajo Nation and Chapter boundaries are from the Navajo Lands Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Structures were interpreted by TerraSpectra Geomatics. Wells are primaily from the Navajo Department of Water Resources and augmented by state water departments and USGS hydrographic datasets. The scores were calculated by TerraSpectra Geomatics using the modified Hazard Ranking System model developed by the U.S. Environmental Protection Agency, Region 9.

N W E S

0 20 Miles

Map Scale 1:450,000

Legend

Range of AUM Scores

- 160 - 450
- 451 - 1700
- 1701 - 5910

Targets

- Structures within 1 Mile of AUM
- Wells within 4 Miles of AUM
- Drainages for up to 15 Miles Downstream from an AUM

Figure 19. Combined Pathways Map with Three Score Ranges.

The following documents are recommended for further review:

- Phase I
  EPA Region 9 Superfund Records Center Archive Index
  Maps, Documents, and Data (CDROM)
  Project Atlas (CDROM)
  EPA - King Tutt Mesa Aggregated Sites Preliminary Assessment/Site Investigation, Expanded Site Investigation and Integrated Assessment reports
- Phase II
  EPA Region 9 Superfund Records Center Archive Index
  Arizona Geological Survey Open File and Contributed Reports (AUM histories—many written by W.L. Chenoweth)
  NM Bureau of Mines and Mineral Resources Open File Reports (AUM histories—many written by W.L. Chenoweth)
  NAMLRP - Mine Reclamation Reports

Based on previous field work in the Red Valley Chapter, EPA recommends additional field assessment to evaluate elevated radionuclide results at the three unoccupied structures near King Tutt Mesa.

The following sites have come to EPA's attention due to elevated radionuclide activity in water samples (EPA, 2000b). The EPA Maximum Contaminant Level (MCL) for uranium is 30 micrograms per liter (µg/L) or 20 pico-curies per liter (pCi/L). MCL is the maximum permissible level of a contaminant in water delivered to users of a public water system. Water samples from the following locations were sampled for Uranium^{234}, Uranium^{235} and Uranium^{238} and the summed total values were greater than 20 pCi/L. The water sources cited were not sampled from Public Drinking Water Systems. The results, a one-time sampling event by EPA, are not definitive with respect to attribution from anthropogenic versus naturally occurring sources. EPA water sampling in the Cove watershed were taken prior to NAMLRP reclamation activity and current conditions may differ. The locations of these water samples with elevated uranium levels are plotted on Figure 20 "Water Sample Locations with Elevated Uranium."

Sample ID	Sample Name	Total Uranium (pCi/L)
RV990907SWW004	9T550	32.30
RV990330CVS010	Alcove Canyon Springs	125.34
RV990518CVS015	Area 1	51.31
RV990518CVS016	Area 4	148.83
RV990518CVS017	Area 2	116.14
RV991026CVM013	Camp Mine	419.66
RV991020CVM012	Cove Mesa 2	879.00
RV990517CVW004	Ellison Wells	34.73
RV991019CVM010	Pipe Mine	67.45
RV990317TNS001	Sah Tah Spring	45.83
RV990907SWW003	Slimwagon Well	76.00
RV990519RVW005	Thumb Rock Well	30.37
RV990519CVW005	Water Well 309	83.71
RV991201RVW013	West Thumb Rock Well	32.80

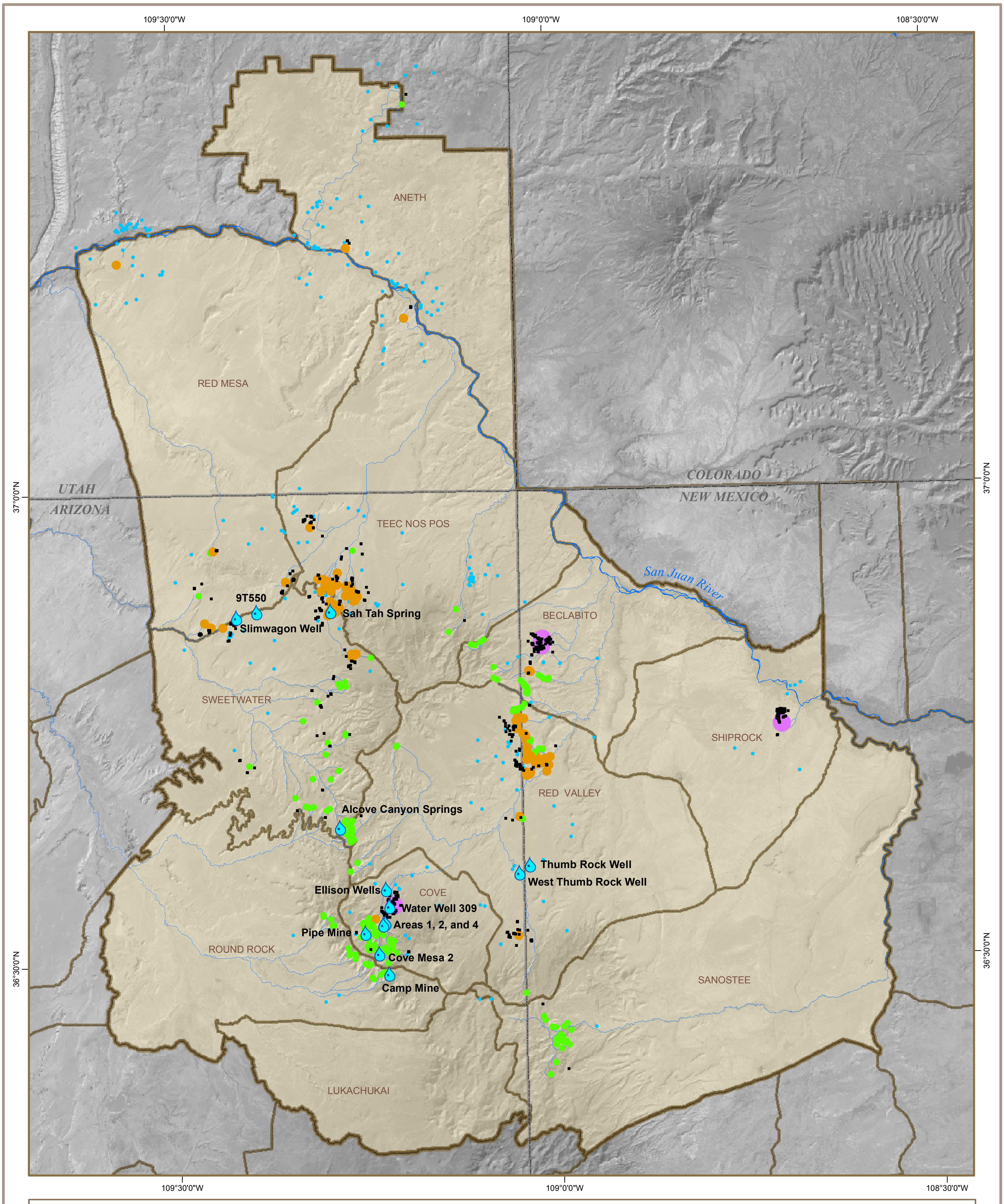
Review of these water sample results suggest that uranium mining may have affected the down-gradient watersheds. An area of interest is the Lukachukai mining area in the southwest portion of Cove Chapter. While the AUM scores are low, there are a series of 8 water samples that indicate elevated levels of uranium downstream from the Lukachukai AUMs, which were highly productive uranium and vanadium mines. Two of the AUMs in the Lukachukai mining area have highly elevated total uranium levels: Camp Mine (419.66 pCi/L) and Cove Mesa 2 (879.00 pCi/L). Based on notes and photos taken during water sampling field visits by the U.S. Army Corps of Engineers, both of these mines had wetland areas proximal to them.

Another area of interest is the Cove Mesa mines in the West Carrizo mining area. This is a highly productive uranium mining area with mines that score low due to their remote locations. The water sample at Alcove Canyon Spring resulted in a total uranium value of 125.34 pCi/L.

Two water sample sites have elevated radionuclide activity, but appear exempt from CERCLA authority:
- Thumb Rock Spring - no apparent AUM nearby
- West Thumb Rock Spring - no apparent AUM nearby

NEXT STEPS

- NNEPA, NAMLRP and EPA should jointly review the report findings.
- NNEPA and EPA should develop a joint CERCLA action plan.
- EPA shall continue to support the Navajo Nation with additional assessment activities at NNEPA and shall address identified high priority areas of concern via the EPA Removal Program, at the request of the Navajo Nation.



ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

Northern AUM Region Screening Assessment Report

WATER SAMPLE LOCATIONS WITH ELEVATED URANIUM

Sources

Water sample locations from the U.S. Army Corps of Engineers. AUM locations are primarily from the Navajo Abandoned Mine Land Reclamation Program (NAMLRP) and augmented by other sources. The Navajo Nation and Chapter boundaries are from the Navajo Lands Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Structures were interpreted by TerraSpectra Geomatics. Wells are primaily from the Navajo Department of Water Resources and state water departments and USGS hydrographic datasets. The scores were calculated by TerraSpectra Geomatics using the modified Hazard Ranking System model developed by the U.S. Environmental Protection Agency, Region 9.

N
W E
S

0 20 Miles

Map Scale 1:450,000

Legend

Elevated Uranium Water Sample

RANGE OF AUM SCORES

160 - 450

451 - 1700

1701 - 5910

TARGETS

Structures within 1 Mile of AUM

Wells within 4 Miles of AUM

Drainages 15 Miles Downstream from AUM

Figure 20. Water Sample Locations with Elevated Uranium.

REFERENCES

NOTE: Reference documents used in the preparation of this Screening Assessment Report were scanned. The electronic versions are included in the accompanying data package, with the exception of documents that are copyrighted, unpublished, draft, considered limited distribution, confidential, sensitive, or proprietary by the document providers. References that are followed by a source reference number (e.g., S02240306) are provided in electronic format and the source reference number is used as the document filename.

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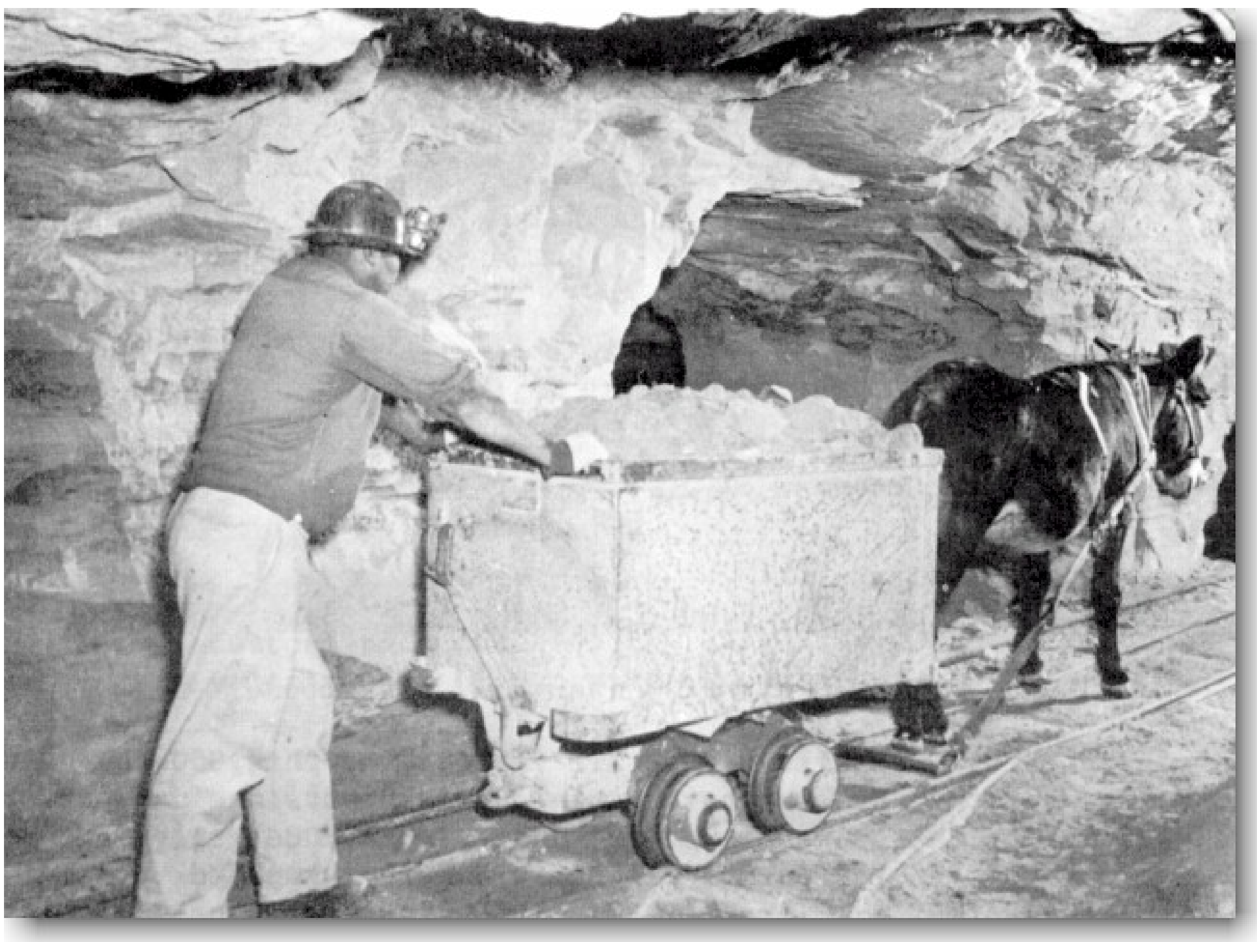


Hauling ore by burro in Frank No. 1 Mine (photo from Dare, 1961)

ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Northern AUM Region Screening Assessment Report

APPENDIX A - GIS DATASETS

STRUCTURES

SCREENING ASSESSMENT TARGETS

One of the data collection objectives for this study is to obtain existing data to support screening assessments. The primary purpose of screening assessments is to distinguish between abandoned uranium mine (AUM) sites that pose little or no threat to human health and the environment, including livestock and wildlife, and those sites that may require further investigation (EPA, 1991). AUM sites in the Northern AUM Region are potential sources of hazardous materials. An important component of assessing potential threats is to identify whether there are any possible "targets", such as people or livestock, located near the sites or potentially impacted through some type of exposure. Some terms related to "targets" that are used throughout this document are provided here to help clarify the discussion.

Target

A target is defined as: "*a physical or environmental receptor that is within the target distance limit for a particular pathway* (ground water, surface water, soil, or air)" (EPA, 1991). Examples of potential targets include wells and surface water used for drinking water, livestock, fisheries, and sensitive environments, such as wetlands and riparian areas.

Target Distance Limit

A target distance limit is the maximum distance over which targets are evaluated. These distances vary by pathway (EPA, 1991). The target distance limits used in the HRS-derived model for the AUM project are:

- Soil Exposure Pathway 1-mile radius around the AUM site
- Air Pathway 1-mile radius around the AUM site
- Groundwater Pathway 4-mile radius around the AUM site
- Surface Water Pathway 15 miles downstream from the probable point of entry to surface water

Target Population

The target population is the human population associated with an AUM site and/or its targets. The target population consists of those people who use target wells or surface water for drinking water, eat food taken from impacted livestock or fisheries, or are regularly present on an AUM site or within target distance limits.

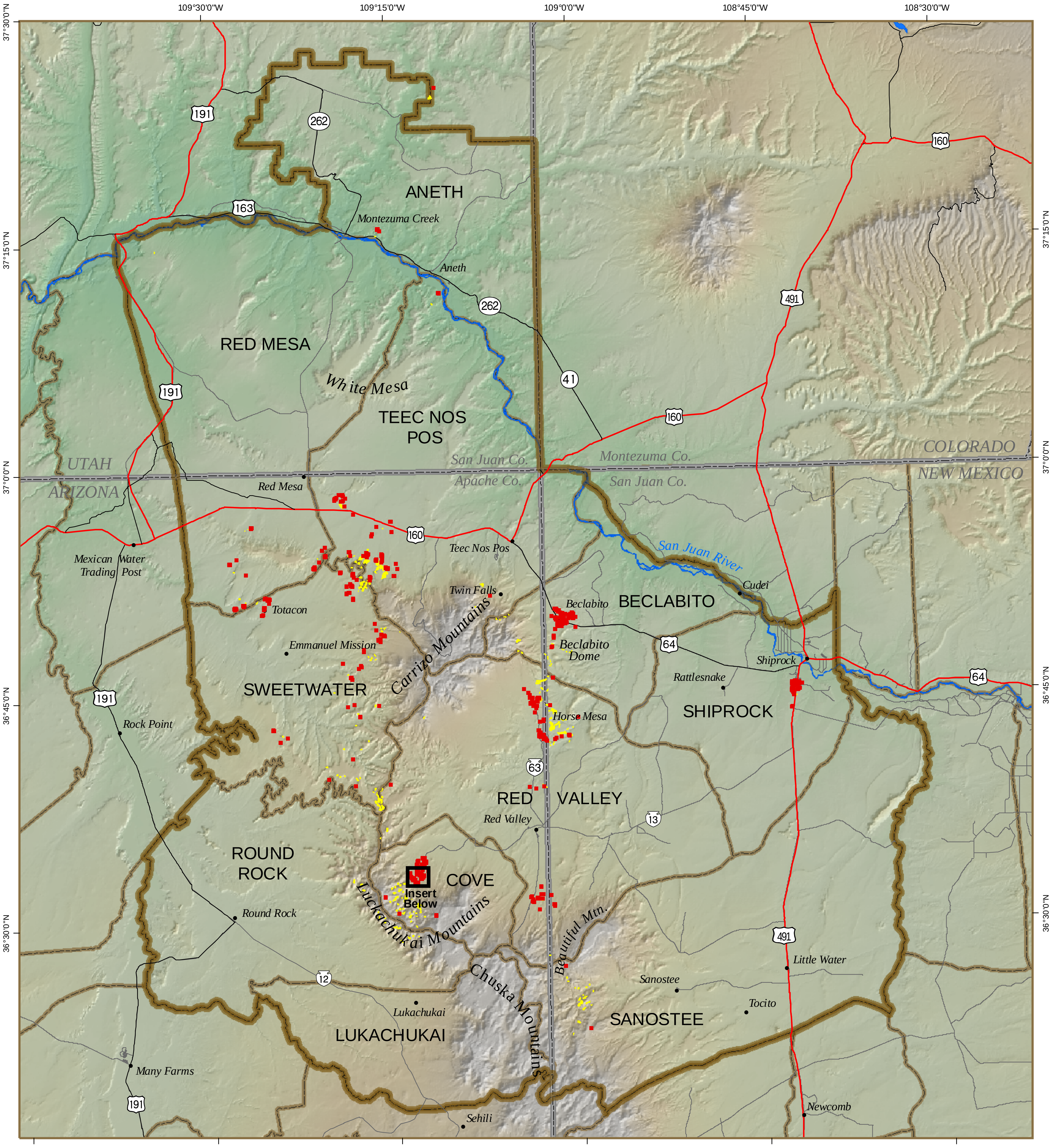
NORTHERN AUM REGION

The Northern AUM Region can be characterized as a rural community. It is sparsely populated throughout a land area of approximately 1,926,032 acres (3,009 square miles) in the hilly, high-altitude plains of the Navajo Nation. The 2000 Census estimated the total resident population for the entire region at 22,358. The summary table below provides the estimated land areas and estimated populations from the 1980, 1990, and 2000 Census for each of the 11 chapters within the Northern AUM Region. This table was developed from Chapter Profile information obtained from the Chapter websites (e.g., www.cove.nndes.org), with the exception of Red Mesa Chapter and Teec Nos Pos Chapter. Red Mesa and Teec Nos Pos Chapter Profile information was extracted from "Chapter Images: 1996" (Rogers, 1997) and the U.S. Census Bureau for the 2000 Census population statistics.

	Estimated Land Area (Acres)	Estimated Land Area (Sq. Miles)	1980 Census	1990 census	2000 census
ANETH	183,780	287	1,641	1,949	2,236
BECLABITO	86,521	135	484	385	522
COVE	44,353	69	397	442	499
LUKACHUKAI	97,080	152	1,580	2,055	1,982
RED MESA*	267,371	418	857	1,174	1,138
RED VALLEY	221,348	346	1,063	968	1,227
ROUND ROCK	201,189	314	655	774	1,287
SANOSTEE	313,576	490	1,943	2,070	1,900
SHIPROCK	125,314	196	6,103	7,850	8,904
SWEETWATER	152,066	238	1,332	1,172	1,340
TEEC NOS POS*	233,433	365	1,250	1,171	1,323
	1,926,032	**3,009**	**17,305**	**20,010**	**22,358**

For the purposes of assessing the potential target population, it is important to know where people live, work, go to school, and where they routinely gather. The locations of current residences were not readily available for the Northern AUM Region. Existing USGS topographic maps include many buildings and other structures of interest. However, a majority of these maps are over 20 years old and still require conversion into a suitable GIS format for analysis. More recent USGS Digital Orthophoto Quarter Quadrangles (DOQQs) were available and were used as a basis to map buildings and other structures. The DOQQs were based on aerial photography acquired in 1997 and 1998. For a small number of features, the older topographic maps were used as an interpretation aid. The Navajo Tribal Utility Authority (NTUA) provided point locations for utility meters for the NTUA service areas within the Northern AUM Region. The meter locations were collected using Global Positioning System (GPS). It was assumed that where there were water, gas, or electric meters there was probably some type of structure present. The NTUA meter data was very useful in mapping the location of structures assumed to have been constructed after 1998.

It was not possible to consistently distinguish residences from other types of structures using the DOQQ imagery. Field verifications were not undertaken for this mapping effort. Residence-sized structures, including trailers were mapped. Some structures may be large sheds or other non-residential structures, and some may be seasonal residences and not occupied full-time. All of these structures, however, are indicative of locations where people might be present in the Northern AUM Region. The map of structures within 1 mile of an AUM site is shown on the facing page.



ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION

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STRUCTURES

0 20 Miles

Map Scale 1:500,000

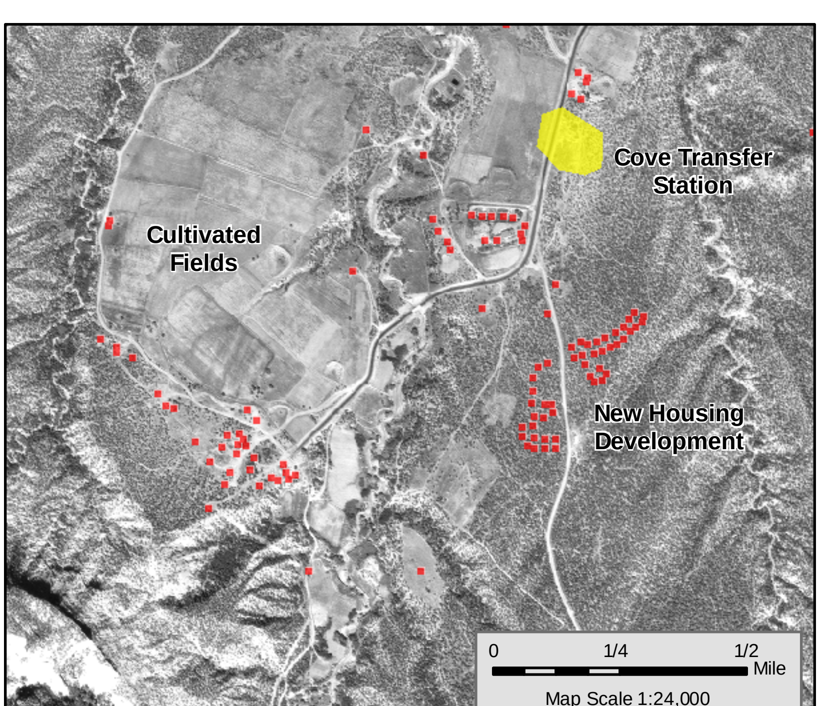
Legend

Structure Within 1 Mile of AUM

Abandoned Uranium Mine

Sources

Structures within 1 mile of abandoned uranium mines were mapped by TerraSpectra Geomatics using USGS Digital Orthophoto Quarter Quadrangles (DOQQs), USGS Topographic Quadrangles, and utility meter locations provided by the Navajo Tribal Utility Authority (NTUA).



Inset showing the location of the AUM transfer station and nearby structures in Cove Chapter. The base image is a DOQQ generated from 1998 photography and shows cultivated fields and drainages. A housing development built after 1998 that was mapped from utility meter locations is also shown.

APPENDIX A - GIS DATASETS

ABANDONED URANIUM MINES

URANIUM MINING

Although outcrops of radioactive minerals exist throughout much of the Navajo Nation, the areas where ore was extracted and deposited in mine waste piles exhibits higher radiation levels than most undisturbed natural areas (OSM, 1999). The excavation of uranium ore bodies is associated with hazards due to both physical hazards and radiation exposure. Radiation is particularly hazardous because it cannot be seen or detected without the aid of specialized equipment. The result is that radiation exposure or contamination is not readily apparent. Hazards associated with abandoned uranium mines (AUMs) include open portals, adits, vertical openings, inclines and declines, radioactive waste piles and dust, rim cuts, highwalls, and embankments (OSM, 1999).

From the late-1940s through mid-1960s uranium ore in the Northern AUM Region was mined mostly from mesa tops, rims, and from canyon walls. Extracted ore was manually sorted at the site. Higher grade ores were transported to buying stations and processing mills and the waste rock consisting of overburden and lower grade ore (proto-ore) was left behind in debris piles. Transporting ore from the Mesa No. 2 mine involved loading ore onto dump trucks and driving down steep, winding dirt roads to the Cove Camp where the ore was dumped and stockpiled. The ore was then reloaded onto larger trucks to haul the ore to the Shiprock mill (Dare, 1961), leaving behind radiation at the surface. Ore bodies at or near the surface of mesa tops were excavated, resulting in relatively shallow pits or trenches. Often the pits were less than 10 feet deep, with unexcavated proto-ore at the base and a proto-ore debris pile on the surface. These debris piles were potentially a new source of radiation at the surface. Buried ore bodies and ore bodies exposed on canyon walls were mined by digging down to the ore, or into the face of a hillside or canyon wall, creating mine entrances (shafts, inclines, declines, and/or adits). The debris pile/talus slope of proto-ore emits gamma radiation at the surface where none may have been emitted before mining (EPA, 1999).

RECLAMATION

Since May 1990, the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) has worked to reclaim eligible AUMs on the Navajo Nation. A scheme for prioritizing non-coal mine sites was established, with Priority 1 sites exhibiting extreme physical hazards, easy access, and danger to life and property. Priority 2 and 3 sites have less physical danger, more difficult access, and lower visitation. Inventories and priorities of AUMs were conducted by the NAMLRP during the period August 1988 through October 1990. NAMLRP compiled information about each reported occurrence of past uranium activity on the Navajo Nation. Field inventories and investigations were then conducted to develop a comprehensive inventory of the AUM sites.

AUM FEATURE LOCATIONS

Mine feature locations (e.g., portals, shafts, rim strips, prospects, waste piles) were provided by the NAMLRP on 7.5 minute USGS topographic maps and coded by mine feature type. These maps were georeferenced and a GIS point dataset was created. There are 870 mapped AUM features, with 417 portals, 9 vertical shafts, 303 rim strips/pits, 136 prospects, 4 waste piles, and 1 drill hole. An example of AUM sites and features in the Red Valley Chapter area is shown on the facing map figure.

AUM BOUNDARIES

NAMLRP also provided maps showing the location of AUM Reclamation Project Areas. NAMLRP project areas generally included groups of mine features that were associated with one or more mining operations. They encompass the mapped mine features, smaller unmapped features of a mining operation, and a buffer around the mining operations by about 50 feet. These NAMLRP project polygons provide excellent mine operation locations and extents. However, in some cases, it was possible to further refine the AUM boundaries by including NAMLRP unreclaimed mine waste piles, airborne radiological anomalies, and/or photo-interpreted mine-related surface disturbances.

The AUMs in the Northern AUM Region mostly occur in areas of high relief, characterized by flat-topped mesas with vertical or near vertical cliffs. Mine waste was often pushed down these cliffs forming potentially radioactive talus slopes of mine waste. These mine waste piles were not individually mapped, however, they were identified by NAMLRP and coded into the mine features GIS dataset. In these areas, the boundaries of NAMLRP project polygons were extended by 200 feet in the down-slope direction.

Some NAMLRP project boundaries were modified based on aerial radiation data collected in 1999 by the U.S. Department of Energy Aerial Measuring System (Hendricks, 2001). USGS DOQQs were also inspected around each NAMLRP project. Boundaries were extended where photo-interpreted mine related disturbances could be mapped outside and adjacent to the NAMLRP project. Some NAMLRP projects encompassed more than one mine. In these cases, NAMLRP projects were split into two or more polygons to enable the separate representation of AUMs. All of the modifications to the NAMLRP project boundaries were documented in the metadata, and resulted in a new GIS dataset of AUM boundaries.

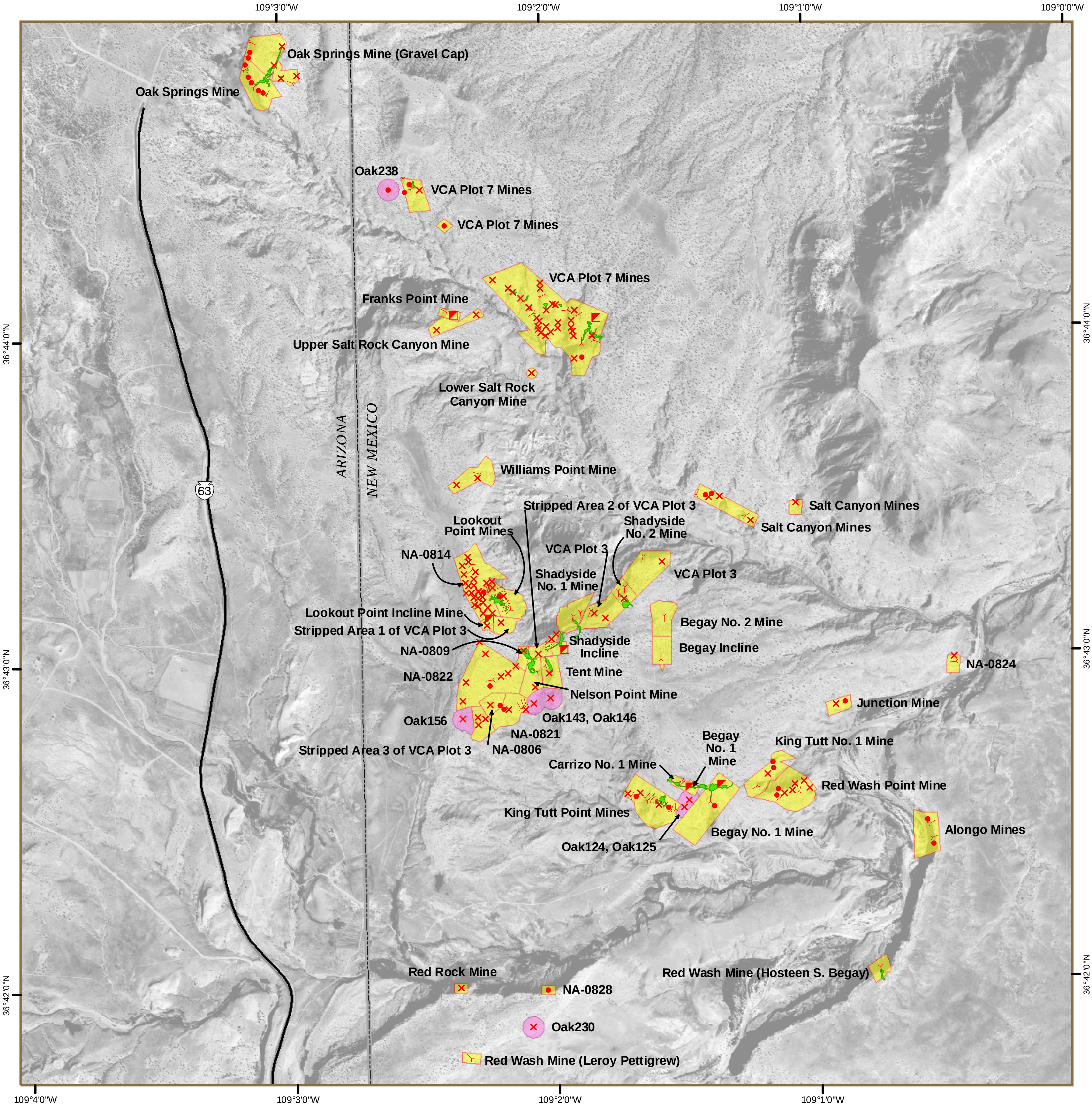
AUM polygons were also generated for mine features and unreclaimed mine waste piles that were not included in the NAMLRP reclamation projects. These AUM polygons were generated by creating a 200 foot buffer around the feature.

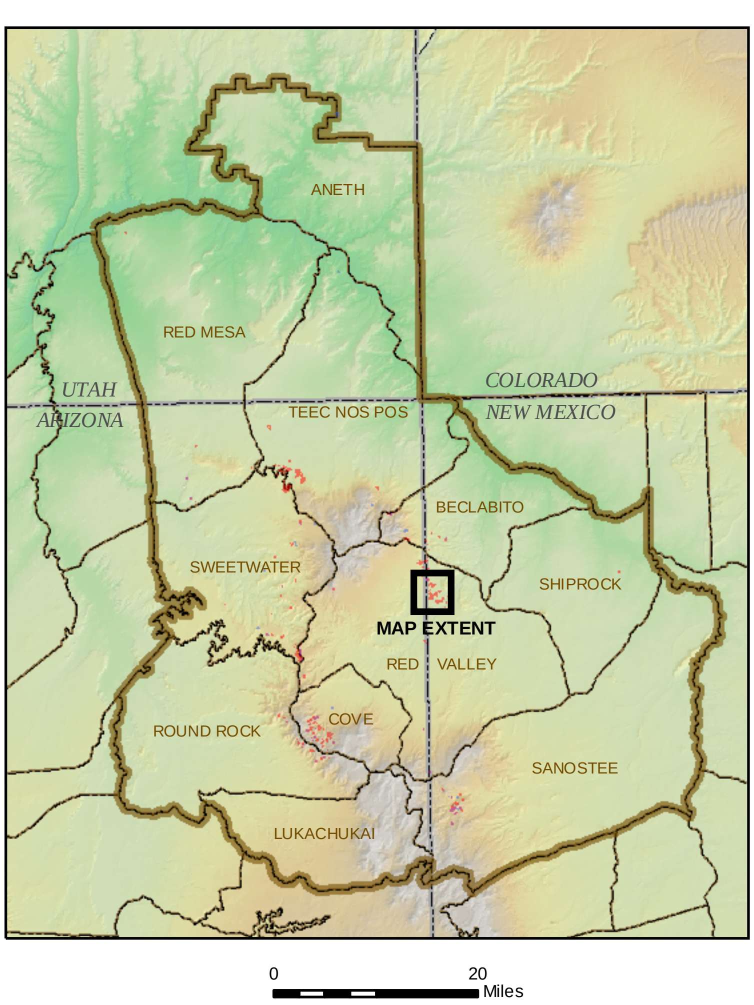
A few AUMs were added to the AUM GIS dataset from sources other than NAMLRP. Examples include: the Pete 6&7 Mine in Aneth Chapter (Sprinkel, 1999); Aneth 1 in the Teec Nos Pos Chapter (Chenoweth, 2005); the Cove Transfer Station (Hendricks, 2001 and Dare, 1961); and the Climax Transfer Station south of the community of Shiprock (Chenoweth, 2006 and NNEPA, 2006).

The final boundaries represent the extents of the surface features associated with the AUMs and were used as the basis for generating buffers for the Soil, Air and Surface Water Pathway analyses.

<u>Underground AUM Workings</u>

A significant number of the AUMs in the Northern AUM Region had extensive underground workings, particularly those in the Lukachukai and Cove Mesa area. Many historical reports contained sketches of the underground workings of the mines, which were used to develop polygon boundaries representing the extents of the underground workings. The combined area of the surface and underground AUM boundaries were used to generate the buffers used for the Groundwater Pathway analyses. Examples of AUM surface and underground boundaries in the Red Valley Chapter area are shown on the facing map figure.





Map Scale 1:1,200,000

ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
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ABANDONED URANIUM MINES (AUM)

N
W E
S

0 1 Miles

Map Scale 1:25,000

Legend

- Reclaimed AUM Sites
- Unreclaimed AUM Sites
- AUM Underground Workings
- Portal (Adit / Incline)
- Prospect
- Rim Strip / Pit
- Vertical Shaft

Sources

Locations for the AUMs were primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by other sources. Designations of the type of mine feature (e.g. portal, prospect, shaft) were also provided by NAMLRP.

NAMLRP determined that some AUM sites were not feasible for reclamation. These unreclaimed mine features were buffered by two hundred feet in order to create Unreclaimed AUM Sites.

The base image is the Horse Mesa NE Digital Orthophoto Quarter Quadrangle (DOQQ) generated from 1997 aerial photography.

WATER SOURCES AND DRAINAGES

WATER SOURCES

Proximity to water sources is a significant consideration when performing a screening assessment. The closer a well or developed spring is located to an AUM, the higher the likelihood that it may be exposed to hazardous substances. The following provides a discussion about water resource management on the Navajo Nation and information about the water sources within the Northern AUM Region.

The rivers, washes, and aquifers that constitute the water of the Navajo Nation are under the jurisdiction of the Navajo Nation Water Code and are subject to the Navajo Nation's water management. The Navajo Department of Water Resources (NDWR) reported in July 2000 that the total domestic water consumption on the reservation was approximately 12,000 acre-feet annually. Per capita water use on the reservation ranges from between 10 and 100 gallons per day depending upon the availability and accessibility of the water supply. By comparison, the average per capita use for neighboring non-Indian communities in Arizona is 206 gallons per day. Approximately 40 percent of the Navajo population on the reservation is without tap water in their homes, and are required to haul water long distances to provide water for their homes. Water haulers sometimes rely on non-potable water sources, such as stock tanks, for potable purposes (NDWR, 2000).

Groundwater is the most heavily used and dependable water source for the Navajo Nation. The NDWR Water Management Branch maintains water resource databases and provides hydrologic information needed to serve the interests of the Navajo people. The Water Management Branch maintains an extensive database of groundwater well information, which is the primary data resource for groundwater information on the Navajo Nation. The database includes over 8,000 well records for the entire Navajo Nation. Data is provided on new wells based on the information documented in the well-drilling permits and the water-use permits. All locations for water sources in the NDWR well database were used for the screening analysis (oil wells and possible oil wells were excluded).

The map figure on the facing page shows the locations of wells and developed springs or water sources within the Northern AUM Region. The GIS dataset was generated using the NDWR well database, and augmented using Arizona Department of Water Resources, New Mexico Office of the State Engineer, Utah Department of Water Resources, National Hydrography Database, Geographic Names Information System, U.S. Army Corps of Engineers water sample locations, USGS Groundwater Site Investigations database, and USGS topographic maps and digital orthophoto quarter quadrangles.

DRAINAGES

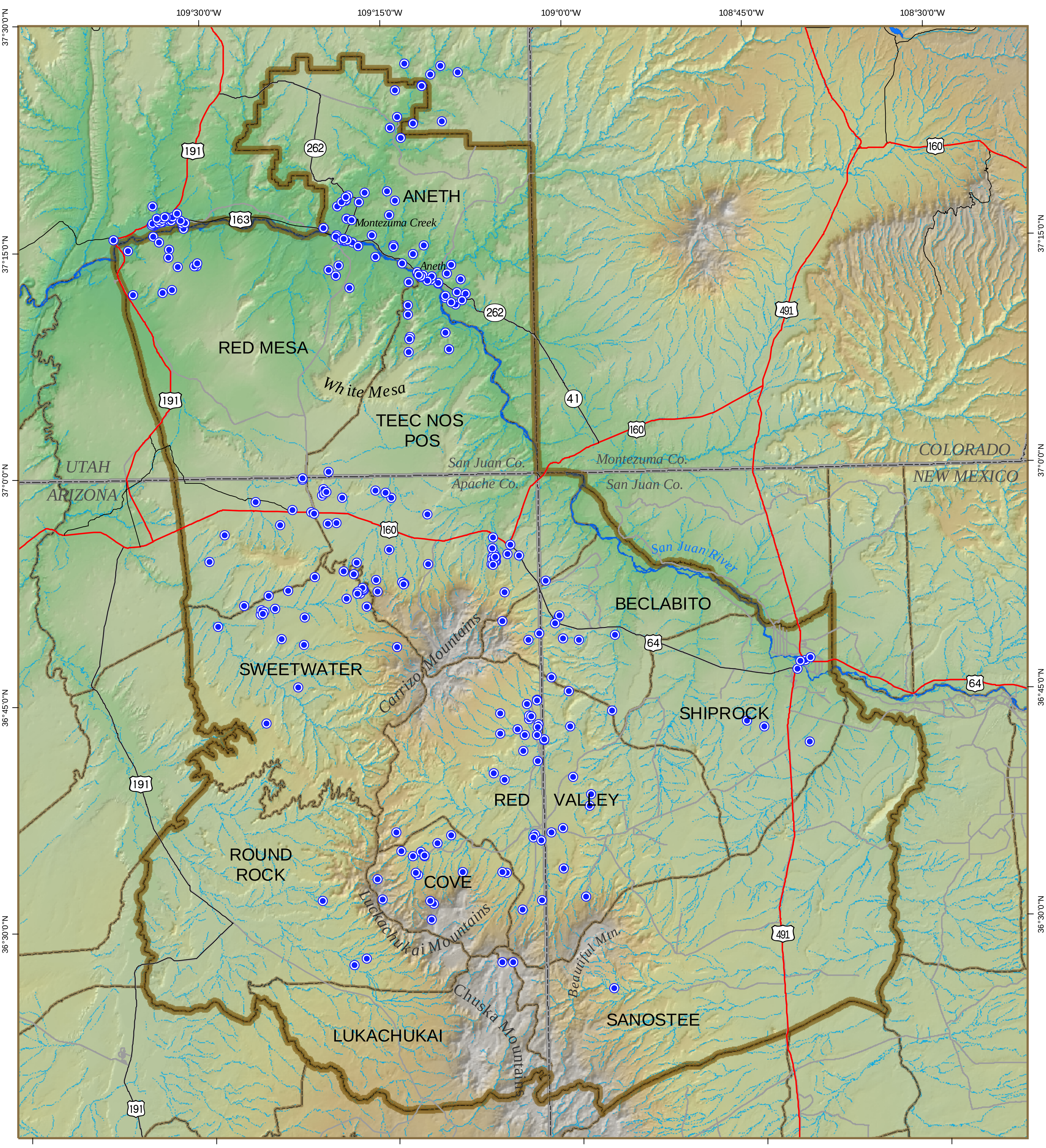
Drainages are important to surface water pathway screening assessments. This factor involves assessing whether potential drainage pathways exist for the transport of hazardous substances to migrate via surface water, and if so, whether any targets (intakes supplying drinking water, fisheries, or sensitive environments) are likely to be exposed to the hazardous substance. In areas, such as the Northern AUM Region, where mean annual precipitation is less than 20 inches, intermittently-flowing waters qualify as surface water.

Erosion is a concern for abandoned uranium mine sites because of the mine wastes. Major sources of erosion/sediment loadings at mining sites include waste rock and overburden piles, haul and access roads, exploration areas, and reclamation areas. The main factors influencing erosion include rainfall/snowmelt runoff, soil infiltration rate, soil texture and structure, vegetative cover, slope length, and erosion control practices. Erosion may cause loading of sediments to nearby drainages, especially during severe storm events and high snowmelt periods. Hazardous constituents (e.g., radionuclides and heavy metals) associated with discharges from mining operations may be found at elevated levels in sediments (EPA, 2000a).

The majority of runoff on the Navajo Nation is to the Colorado River, the master stream of the Colorado Plateau. Most of the Navajo Nation is drained by two principal tributary streams, the San Juan and the Little Colorado Rivers. The Colorado and San Juan are the only major perennial streams, all other streams are either ephemeral or intermittent (Cooley et al., 1969). Perennial streams have visible water flowing above the streambed year-round. Intermittent streams flow water part of the time in most years and have a defined stream channel. Ephemeral streams flow water in response to heavy rainfall events and do not have a defined stream channel. Stream flow in the intermittent channels is also dependent on storm events. Differences in rainfall patterns cause stream flow to be extremely variable. Approximately one-half of the annual precipitation occurs from July through October, generally in the form of localized, short-duration, high-intensity thunderstorms. These storms may create large flows, which are commonly of limited duration and extent.

The type of soil, and the amount and type of vegetation, have a significant effect on the amount of precipitation that becomes surface runoff. As previously stated, much of the runoff in the Northern AUM Region is ephemeral and intermittent and is in response to irregular precipitation events. Runoff of the streams tributary to the San Juan River tends to be sporadic and is controlled largely by three factors: interception; transmission losses; and effect of convectional and frontal storm systems. The unconsolidated surficial deposits intercept and absorb much of the precipitation and the accompanying overland and channel flow. Much of the water intercepted is retained near the surface and is evaporated and transpired.

The surface water stream drainages in the Northern AUM Region are shown on the map figure on the facing page.



Slimwagon Well located near the northwest border of the Sweetwater Chapter.

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WATER SOURCES AND DRAINAGES

N
W E
S

0 20 Miles

Map Scale 1:500,000

Legend

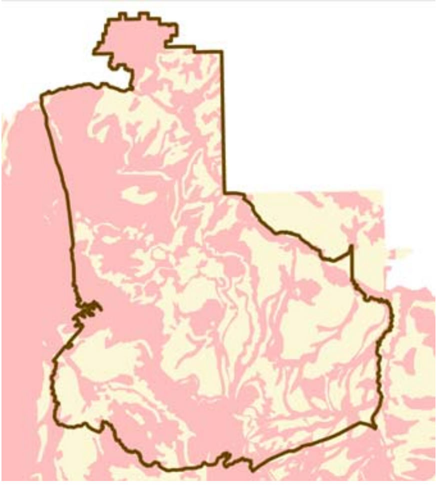
Wells Within 4 Miles of an AUM
Intermittent Stream
Perennial Stream

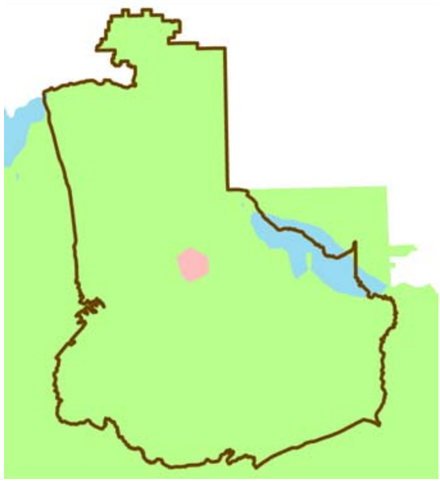
Sources

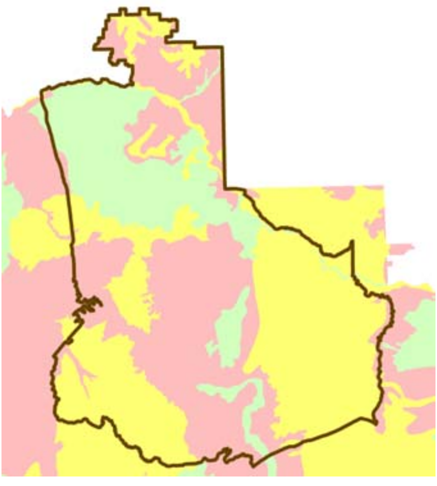
Water sources are primarily from the Navajo Department of Water Rsources (NDWR) and augmented with data from state water departments and U.S. Geological Survey (USGS). The water sources include wells and developed springs. The perennial and intermittent streams are from the National Hydrography Dataset (NHD).

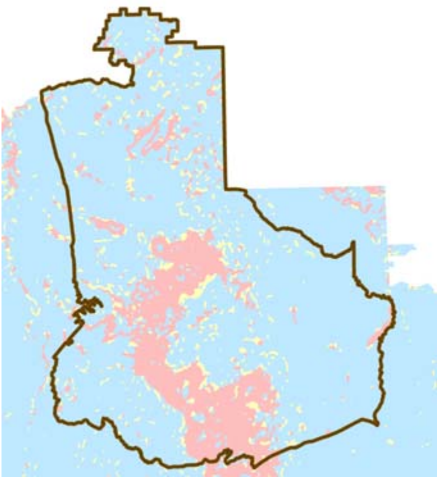
APPENDIX A - GIS DATASETS

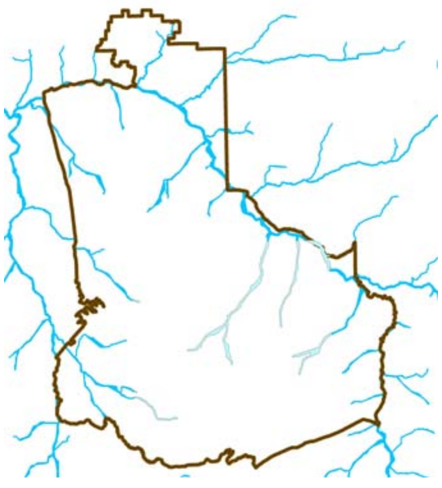
AQUIFER SENSITIVITY


Geology


Precipitation


Soil Properties


Slope of the Land Surface


Fourth-order Stream Courses

Blanchard (2002) cites the definition of aquifer sensitivity as "the relative ease with which a contaminant applied on or near a land surface can migrate to the aquifer of interest. Aquifer sensitivity is a function of the intrinsic characteristics of the geological materials, and the overlying unsaturated zone."

Blanchard's model was developed using broad physical characteristics to describe aquifer sensitivity to surface and near surface contaminants. The model can be applied to the movement of radionuclides and heavy metals to the underlying groundwater. The aquifer sensitivity model complements the screening assessment presented in this report, but was not used in the scoring model.

The factors used in the Blanchard model include geology, precipitation, soil properties, slope of the land surface and stream courses. Blanchard stated that the largest limitation on this method was inadequate information on depth to the uppermost aquifer. Each of these factors for the Northern AUM Region is shown at the left. The following describes the inputs used in Blanchard's (2002) assessment.

The geology was developed from Cooley et al. (1969). It identifies where consolidated rocks are recharged and unconsolidated deposits are at the surface (pink on the geology map at left) and facilitate aquifer contamination. Geology acts as a surrogate for impact of the vadose or unsaturated zone. Yellow identifies areas that do not contribute to recharge.

Water provides the solvent in which contaminants are transported from the land surface to the aquifers. Precipitation is the surrogate for recharge where greater precipitation results in greater potential for contaminants to infiltrate the land surface. In the precipitation map at left, pink indicates high precipitation and most potential to facilitate contamination. Green indicates intermediate, and blue indicates least precipitation and potential to facilitate aquifer contamination.

Several soil properties contribute to the potential to facilitate aquifer contamination, including: texture, infiltration rate, drainage, and organic content. These properties were developed from a modified version (Schwartz and Alexander, 1995) of the STATSGO, or State Soil Geographic database created by the U.S. Department of Agriculture, National Resources Conservation Service. Blanchard further describes that finely textured soil reduces the rate at which water and contaminants move through the soil (low hydraulic conductivity). High infiltration rates indicate a soil that permits a high volume of water to enter from the land surface. Lower drainage rates indicate a higher resident time. Soil organic content affects microbial activity and sorption. Blanchard found that soils on the Navajo Nation had an organic content of less than 2 percent, indicating minimal microbial activity and sorption. With no relative difference across the Navajo Nation, organic content was not used. A soil with a larger potential to facilitate aquifer contamination (green on the soil properties map at left) is coarse-grained, has a high infiltration rate, is well drained, and has a low organic content. Yellow indicates areas with intermediate potential, and a lower potential soil (pink on the soil map at left) is fine-grained, has a low infiltration rate, is poorly drained, and has a high organic content.

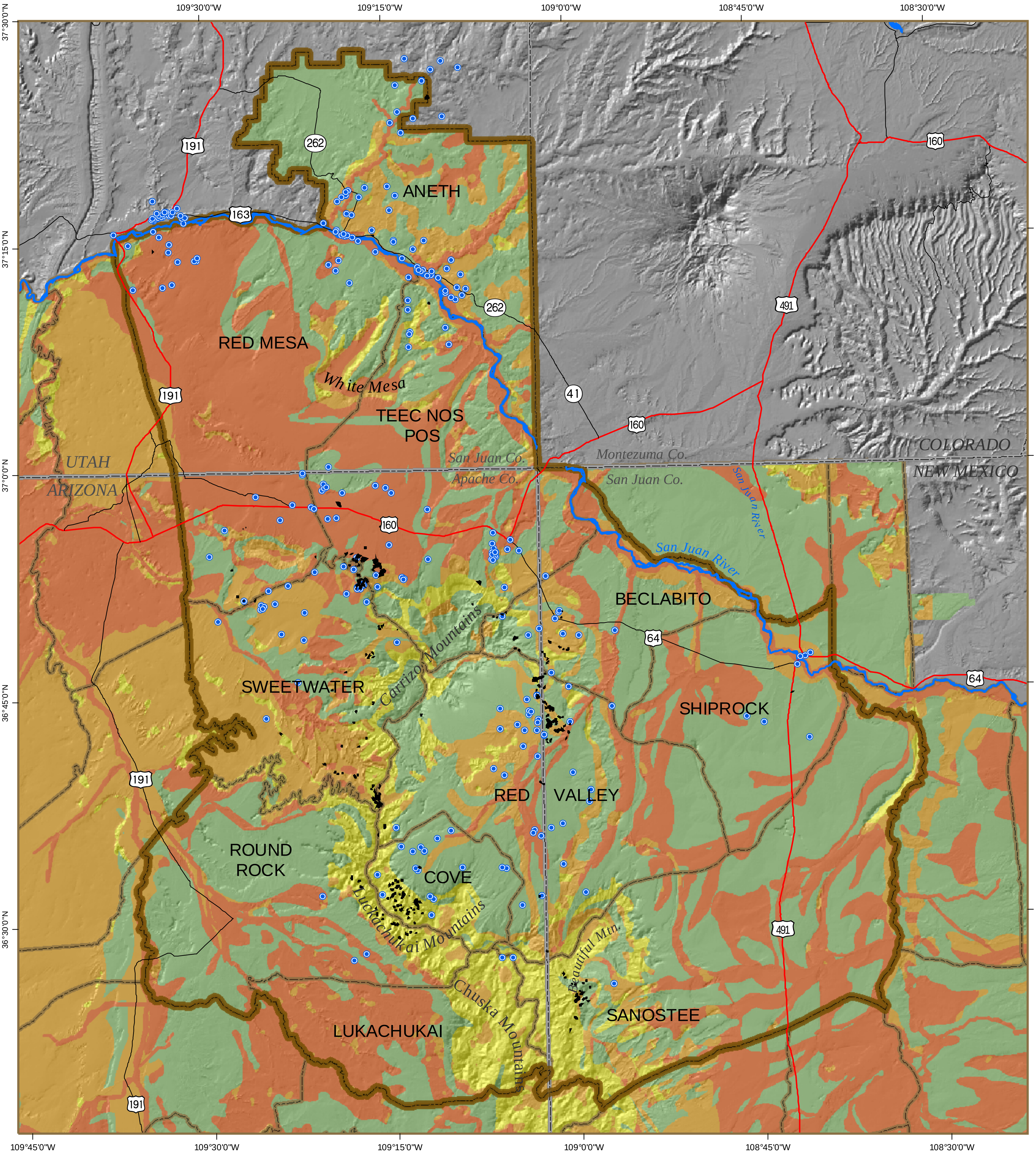
Land surface slope affects the ability of precipitation to infiltrate soil. Slopes less than 6 degrees (blue in the slope map at left) permit precipitation to stay in contact longer with the soil, thereby increasing infiltration of water into the land surface. Conversely, slopes of 6 to 12 degrees (intermediate slopes shown in yellow) and steep slopes greater than 6 degrees (pink in the slope map at left) minimize infiltration because water runs off quickly.

Blanchard developed buffered fourth-order and higher stream courses from USGS DEM's. Stream courses, wherever they occurred, were assigned the greatest potential to facilitate contamination because they concentrate runoff and have flat slopes. Floodplain and terrace soils are also composed of materials that highly facilitate contamination.

Blanchard summed the assigned numeric scores for each of the precipitation, soil properties, and slope layers and multiplied by the geology score (1 = facilitates contamination and 0 = does not facilitate contamination).

A final aquifer sensitivity map was developed from these scores and is shown on the map figure on the facing page. The highest scores represent the areas with most potential for contamination, low scores represent areas with the least potential, and intermediate scores represent areas with intermediate potential. The insignificant category represents areas where the geology score was zero or were not areas of recharge to bedrock aquifers and/or areas of unconsolidated deposits (stream alluvial deposits).

Aquifer sensitivity was not incorporated into the screening assessment scoring model used in this report. It is presented here to illustrate the concept of how this type of geospatial information could be used to develop additional screening criteria.



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AQUIFER SENSITIVITY

N
W E
S

0 20 Miles

Map Scale 1:500,000

Sources

The aquifer sensitivity was developed and provided by Paul Blanchard (2002) U.S. Geological Survey, Water Resources Division in Albuquerque, New Mexico. The data are from a Water-Resources Investigations Report 02-4051 titled "Assessments of Aquifer Sensitivity on Navajo Nation and Adjacent Lands and Ground-Water Vulnerability to Pesticide Contamination on the Navajo Indian Irrigation Project, Arizona, New Mexico, and Utah."

Aquifer sensitivity, which is shown above on a shaded relief image, refers to the potential to contaminate the ground water - ranging from an "insignficant" to the "most" potential. This was determined by an investigation of the geology, precipitation, soils, slope, and stream courses of the area.

Legend

Aquifer Sensitivity Class

- 0 - Insignificant Potential
- 1 - Least Potential
- 2 - Intermediate Potential
- 3 - Most Potential
- Wells
- Abandoned Uranium Mines

APPENDIX A - GIS DATASETS

AERIAL RADIATION SURVEYS

Aerial radiation surveys were flown in October 1994 by the U.S. Department of Energy's (DOE) Remote Sensing Laboratory to evaluate whether the remote sensing technology could provide useful information for locating and characterizing AUMs. One of these initial survey areas covered most of the East Carrizo mining area, and all of the King Tutt Mesa Aggregate mine site (KTM).

The KTM survey was flown using a helicopter-based acquisition platform equipped with custom 2 x 4 x 16 inch log type thallium-activated sodium iodide (NaI[Tl]) scintillation detectors. The BO-105 helicopter was configured with a total of 8 log detectors. Aircraft position was established using a real-time differential Global Positioning System (GPS) and a radar altimeter. Gamma rays detected by the NaI(Tl) detectors were digitized and sorted in the data acquisition system to produce second-by-second records of the gamma ray spectrum. Because every radioactive material has a unique set of gamma rays, a spectrum can be used to identify and separate the sources of the detected gamma radiation.

The survey was flown at an altitude above the terrain of 150 feet, resulting in a nominal footprint of 300 feet, and a line spacing of 250 feet. Radiation sensor measurements were integrated and recorded at one-second intervals. Each measurement provided an average radiation level for the entire ground sample area. This means the data does not pinpoint the radiation levels within the ground sample area, (i.e., the 300 feet diameter footprint under the helicopter). For each ground sample area, the radiation source could be evenly distributed or it could be made up of a combination of radiation sources, such as a higher-level mine waste debris pile placed on soil that had lower regional radiation levels. Obtaining finer detail measurements of an individual radiation source requires additional ground-based measurements.

The DOE Aerial Measuring System (AMS) survey capability was subsequently used to measure and map radiation sources within known uranium mining areas across the Navajo Nation. Helicopter surveys in the Red Valley South, Round Rock, Lukachukai, Sanostee, and Tsetah survey areas were conducted in 1999. These 1999 surveys were flown at a line spacing of 300 feet. Analysis of the 1994 surveys had revealed that increasing the line spacing to 300 feet resulted in no apparent loss of data resolution and permitted an increase in operational data collection efficiency (Hendricks, 2001).

The table below provides summary information for the aerial radiation surveys that were flown in the Northern AUM Region.

Aerial Radiation Surveys in the Northern AUM Region - Summary Information

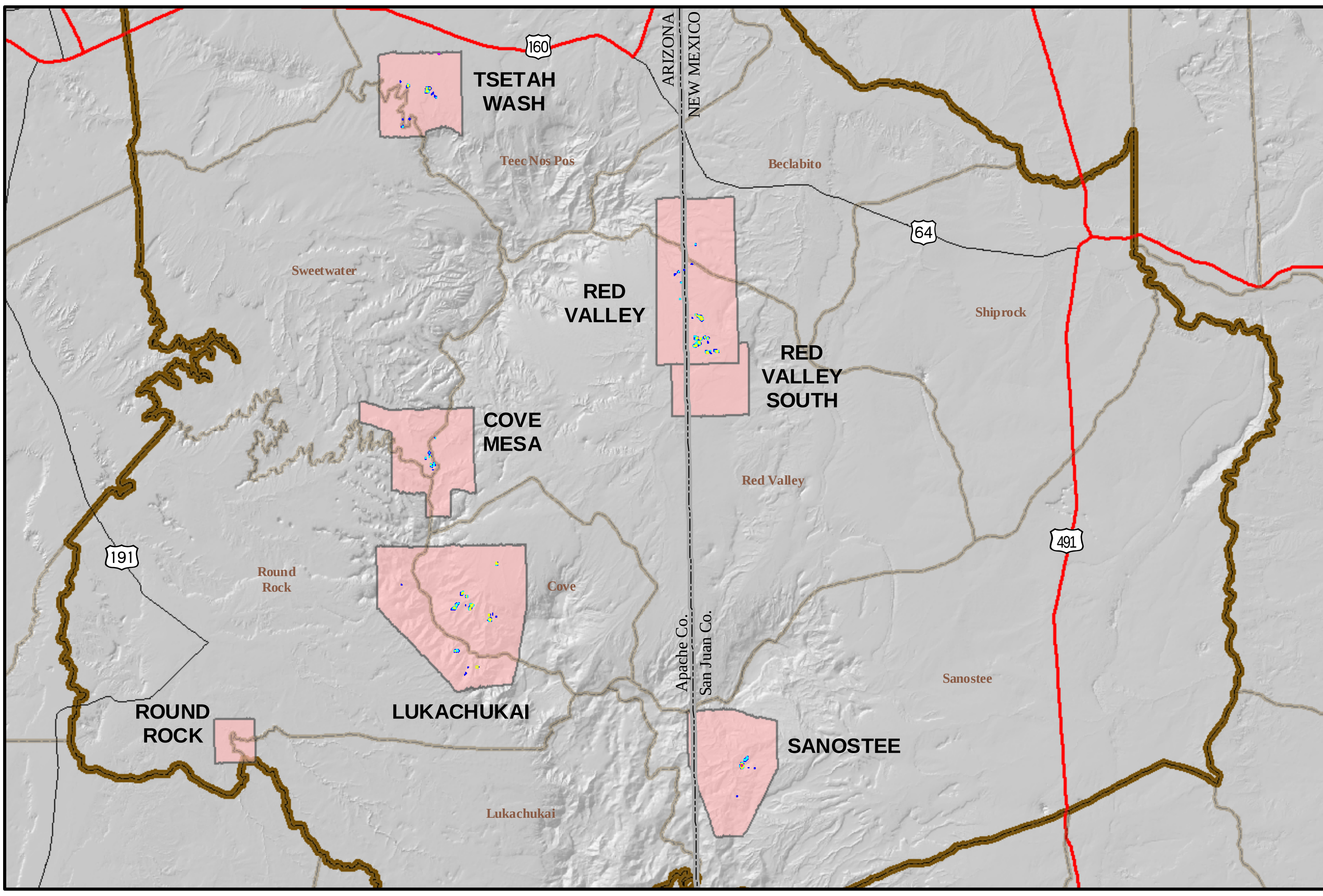
Area Name	Sub Area Name	Original Survey Name	Survey Start End	Survey Areas (sq. miles)	Terrestrial Exposure Rate in uR/hr Does not include cosmic which ranges from 5.1 @ 4000 ft to 9.7 @ 9000 ft elevation				Total # Survey Samples	Excess Bismuth Greater than 80 cps (Approx 3.5 uR/hr)		Notes
					avg	dev	min	max		# of samples	Approx acres	
Four Corners	Cove Mesa	Cove Mesa	10/25/94 10/26/94	20.11	5.58	1.2	3.47	52.69	18,499	65	45.2	1,3
	Lukachukai	Lukachukai	10/14/99 10/20/99	42.29	6.89	1.7	3.23	34.68	27,623	202	197.9	1,4
	Red Valley	Beclabito	10/22/94 10/25/94	33.04	5.37	2.38	2.69	41.52	30,156	292	204.8	1,3
	Red Valley S	Red Valley S	10/15/99 10/18/99	13.50	5.36	1.27	2.92	42.23	9,756	81	71.7	1,4
	Round Rock	Chinle B	05/25/99	4.35	5.45	1.39	2.55	13.22	2,998	1	0.9	2,4
	Sanostee	Sanostee	10/13/99 10/14/99	21.27	7.1	3.02	3.08	82.62	15,440	81	71.4	1,4
	Tsetah	Rattlesnake	10/20/99 10/22/99	16.18	5.27	1.19	3.54	38.62	15,048	100	68.8	1,3

Key for Notes: 1 = BO105 helicopter with 8(2x4x16) gamma detectors
2 = B412 helicopter with 12(2x4x16) gamma detectors
3 = 250 foot line space,
4 = 300 foot line space

The radiation data that were collected for the Northern AUM Region are provided in two forms: gross count and excess Bismuth^{214}. Bismuth^{214} radiation is indicative of the presence of uranium, making it a good indicator of old mines and mining related activities. The Bismuth^{214} response, rather than a uranium response, is used because its unique photo peak can be readily distinguished from other radiation. The aerial survey areas and the Bismuth^{214} radiation contours are shown in the top map figure on the facing page. These aerial radiation contours were used as an aid in locating and defining the surface extents of abandoned uranium mines.

Gross count measures total terrestrial gamma activity, without considering its source, much like a Geiger counter. Aerial gross count data documents the wide range of radioactivity present, even in areas not associated with uranium mining activities. The KTM gross count radiation contours are shown on the bottom map figure on the facing page.

For a more comprehensive explanation of the acquisition and processing methods used for the aerial measurements of radiation, a report has been developed by the DOE's Remote Sensing Laboratory titled "An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation." (Hendricks, 2001).

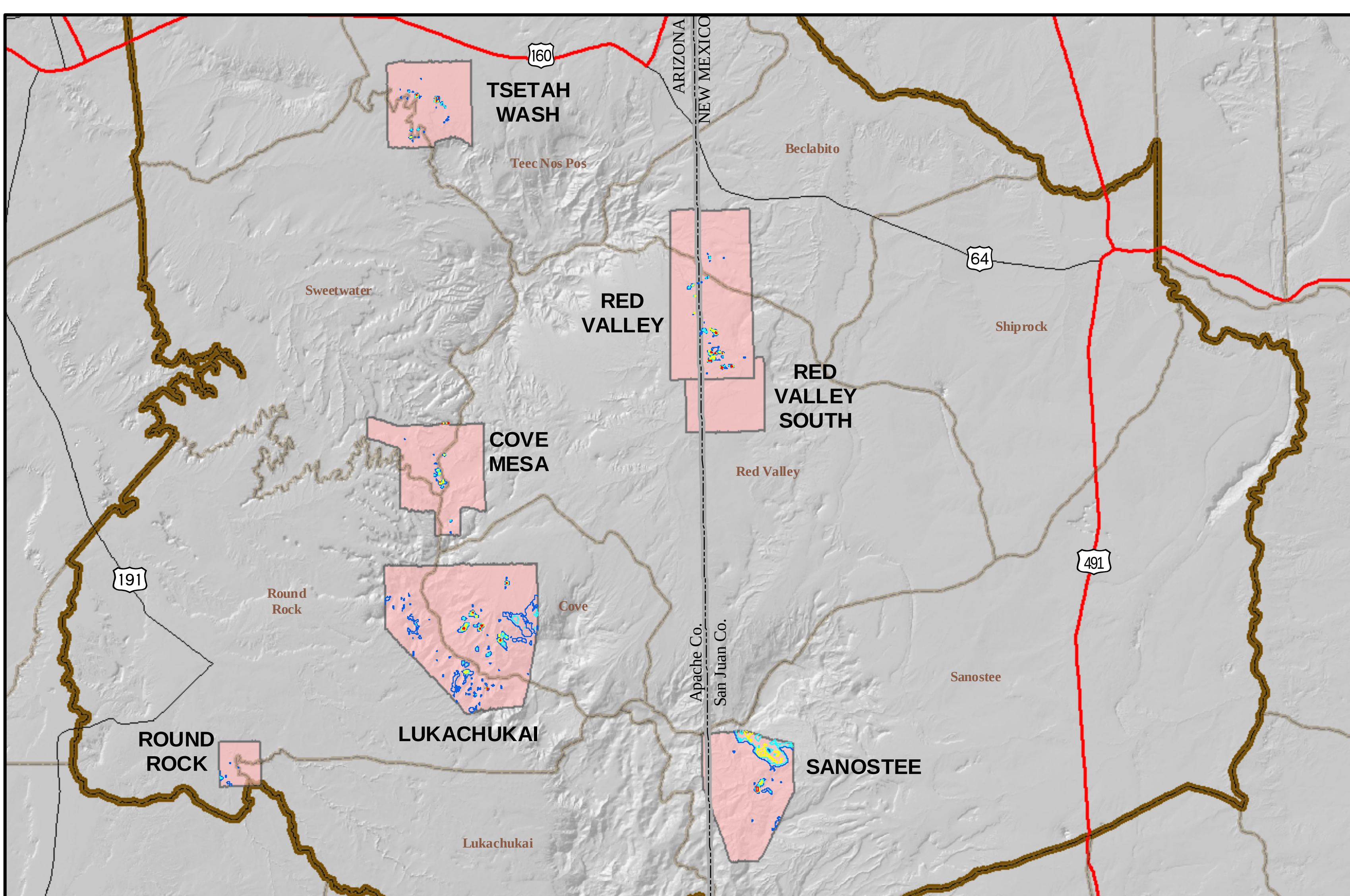


AERIAL RADIATION SURVEY AREAS AND BISMUTH 214 RADIATION CONTOURS

Radiation Contours	Derived contour level Bismuth-214 photo peak (excess counts/sec)	Estimated exposure rate from excess Bismuth-214 (excess µR/hr)
	80	3.5
	120	7.4
	250	10.9
	800	34.9
	1200	52.4

0 10 Miles
Map Scale 1:300,000

Aerial Survey Boundary



AERIAL RADIATION SURVEY AREAS AND GROSS COUNT RADIATION CONTOURS

Radiation Contours	Derived terrestrial exposure rate at 1 meter above ground level. Does not include cosmic contribution. Units in µR/hr.
	9
	12
	16
	24

0 10 Miles
Map Scale 1:300,000

Aerial Survey Boundary

APPENDIX A - GIS DATASETS

DIGITAL ORTHOPHOTO QUARTER QUADRANGLE (DOQQ) IMAGES

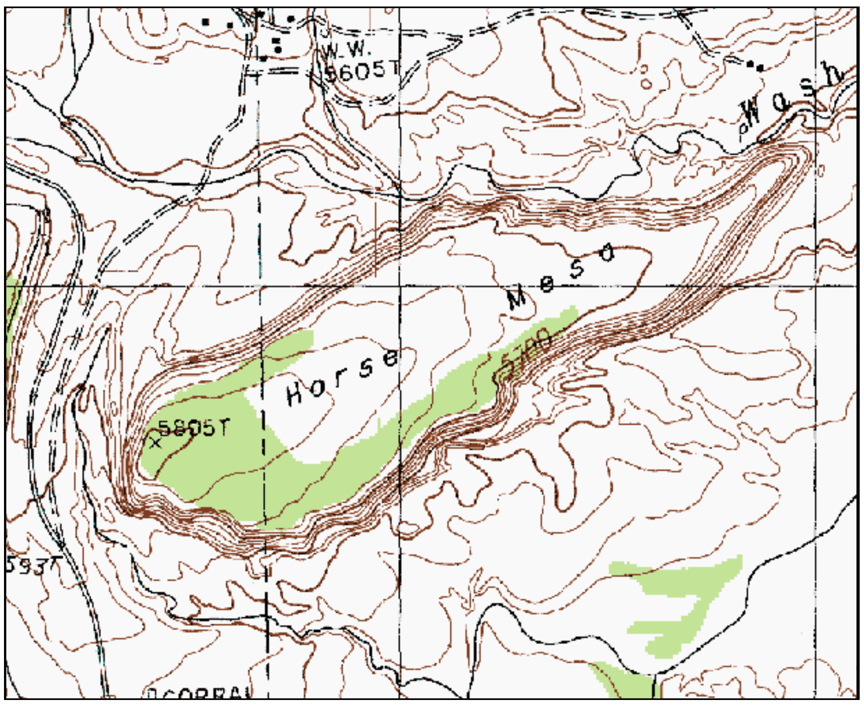
While a conventional aerial photograph looks very similar to an orthophotograph (referred to as orthophoto hereafter), it contains image distortions caused by the tilting of the camera and terrain relief (topography). These distortions result in a non-uniform scale across the aerial photo. You cannot accurately measure distances on an aerial photograph like you can on a map, and the effect worsens as the terrain increases.

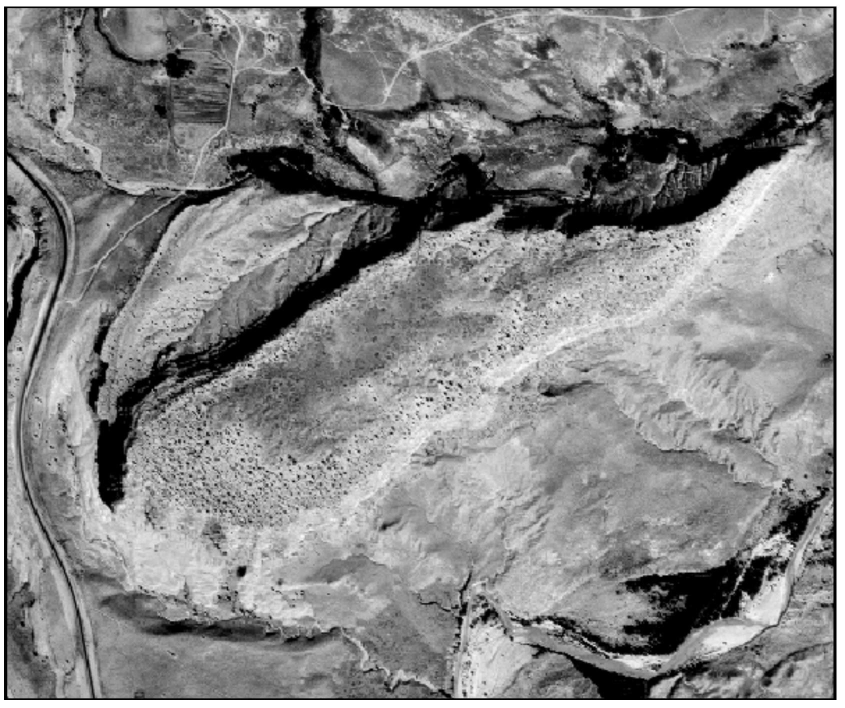
The effects of camera tilt and relief can be removed from aerial photographs by a mathematical process called rectification. Digital orthophotos are computer-generated images of an aerial photograph in which image displacements caused by terrain relief and camera tilts and lens distortions have been removed. The aerial photographs are scanned and processed to create a georeferenced and planimetrically accurate digital image. The production of an orthophoto requires accurate ground control points, camera orientation parameters, and a digital elevation model. The resulting digital orthophoto combines the image characteristics of a photograph with the geometric qualities of a map.

DOQQs produced by the U.S. Geological Survey (USGS) are either gray-scale, natural color, or color-infrared images. Currently, only gray-scale DOQQs are available from the USGS for the Northern AUM Region. A DOQQ covers an area measuring 3.75-minutes longitude by 3.75-minutes latitude, or 1/4 of the area covered by a USGS 7.5-minute topographic quadrangle. The names of DOQQs are based on the USGS 7.5-minute quadrangles, followed by a NE, NW, SW, or SE. An index of 7.5-minute topographic quadrangle boundaries and quadrangle names, and the associated DOQQ boundaries are shown on the map figure on the facing page.

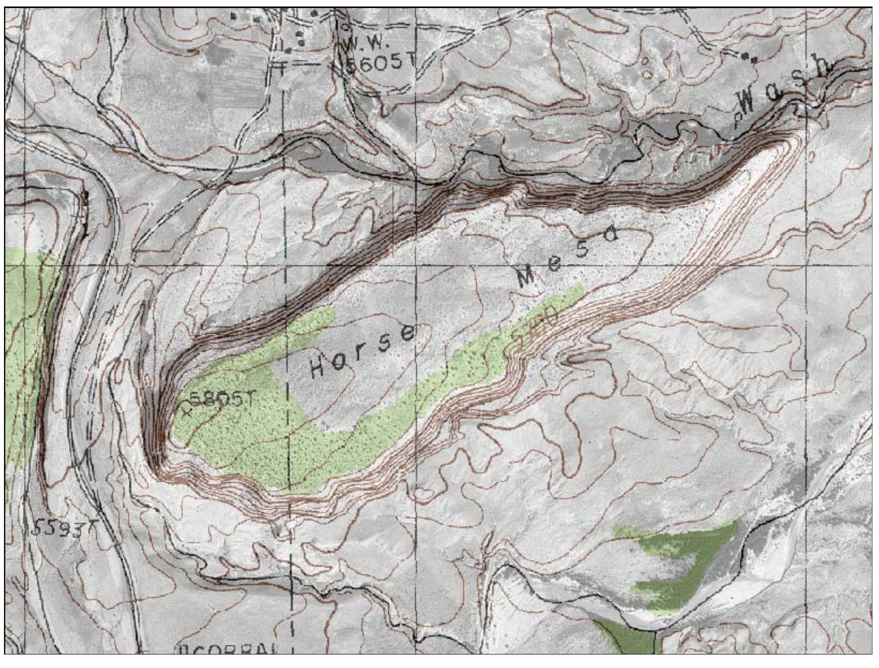
A DOQQ can be used in most any GIS that can manipulate raster images. DOQQs can be used as a cartographic base for displaying other digital spatial data. The accuracy and detail provided by the DOQQ allow users to evaluate their data for accuracy and completeness, make modifications to their data, and even generate new thematic layers. The DOQQs were used extensively in the review and correction of several spatial datasets prepared for this Northern AUM Region screening assessment. The DOQQs were also used to generate new data layers, such as the structures mapping.

The DOQQs for the Northern AUM Region were generated by the USGS using 1997 and 1998 aerial photography. Any housing developments after this period, such as new roads or buildings (e.g., the Mitten Rock housing community), will not be present on the DOQQs. The accuracy and quality of USGS DOQQs meet National Map Accuracy Standards at 1:12,000 scale. DOQQs have a 1-meter ground resolution, and accuracy of +/- 33 feet.



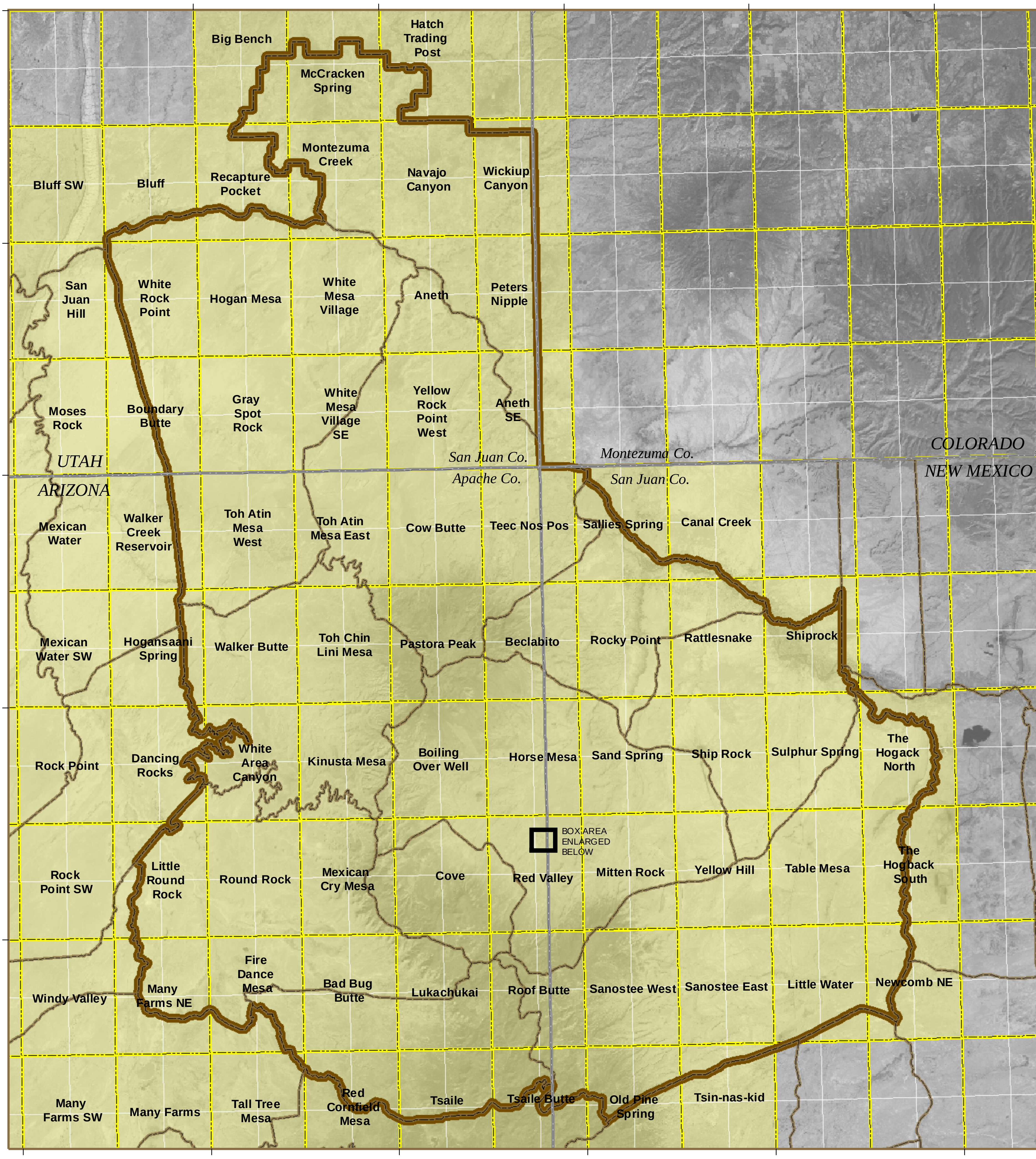


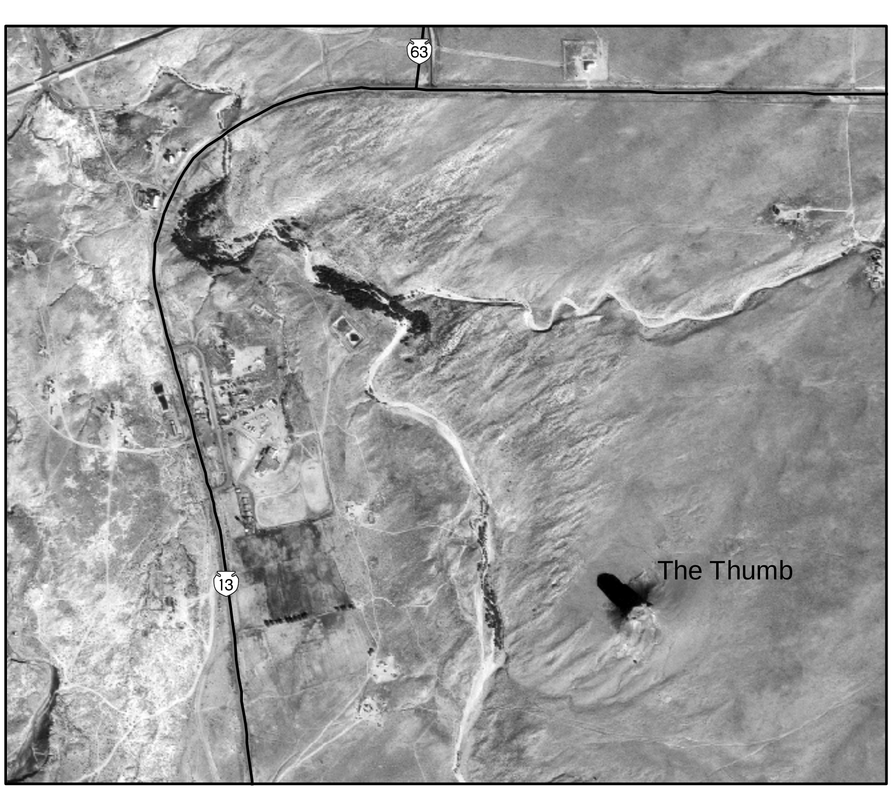
Shown above is an example of a scanned USGS topographic quadrangle map (left) and a DOQQ (right) of the Horse Mesa in Red Valley, AZ-NM.



Shown above is an example of the scanned USGS topographic quadrangle map overlain on the DOQQ of the Horse Mesa in Red Valley, AZ-NM. These images are shown to illustrate the different information that each can provide.

U.S. Geological Survey, 2001. "Digital Orthophoto Quadrangles, Fact Sheet 057-01." (S05150301)





Portion of a DOQQ showing the community of Red Valley. "The Thumb" can be seen in the lower right portion of the image. The insert is shown at a scale of 1:24,000 (1 inch = 2,000 feet).

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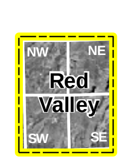
DIGITAL ORTHOPHOTO QUARTER QUADRANGLE (DOQQ) INDEX

N W E S

0 20 Miles

Map Scale 1:500,000

Legend



USGS 7.5-minute topographic quadrangle boundary and quadrangle name for DOQQs used for the Northern AUM Region.

Source

Digital Orthophoto Quarter Quadrangles (DOQQ) are generated by the U.S. Geological Survey (USGS).